ENGINEERING

THE UNIVERSITY OF MICHIGAN
JUL 1961

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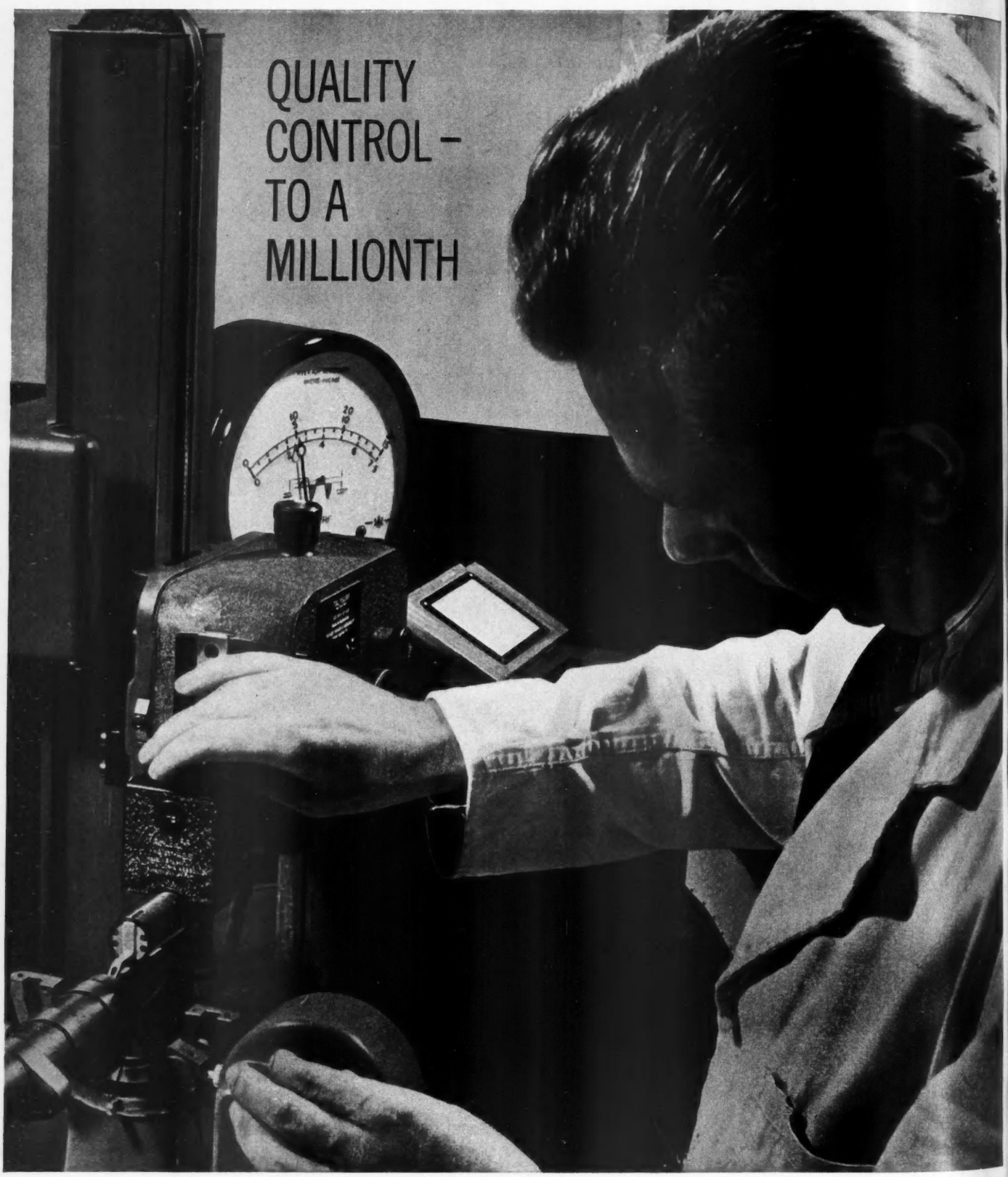

C.A.V. LIMITED, ACTON, LONDON W.3

AP1M

19 May 1961

Vol. 191 No. 4961

Founded in 1866

ENGINEERING

PUBLISHED EVERY FRIDAY

36 Bedford Street London WC2 England Telephone: Temple Bar 3663

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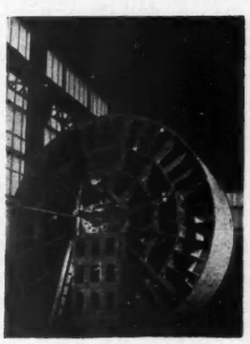

Cover Picture:

The rotor for an air pre-heater for Braehead power station. Two pre-heaters will be installed for each radiant boiler with an evaporation capacity of 550,000 lb per hour. Each rotor is 18 ft 6 in in diameter and when complete weighs 97 tons. (*Nurnberg photograph for* ENGINEERING)

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May 29-30	Machine tools and miscellaneous stores including	W.D. Storage Depot, South West Stores, Euxton Lane, Chorley, Lancs. (Sale at Cheetham Town Hall, Manchester, 8)	J. H. Norris & Son (Dept. J), 9, Albert Square, Manchester, 2. (Tel.: Blackfriars 8373)
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June 1	Miscellaneous stores	W.D. Storage Depot, Ruddington, Notts.	Walker, Walton & Hansen (Dept. J), Byard Lane, Bridlesmith Gate, Nottingham. (Tel.: 54272)
June 7	Machine tools and miscellaneous stores	Technical Stores Depot, Old Dalby, Leics. (Sale at Melton Mowbray)	Shoulder & Son (Dept. J), 1, Norman Street, Melton Mowbray, Leics. (Tel.: 3081)
June 21	Machine tools and miscellaneous stores	Northern Command Ordnance Sub. Depot, Nr. Selby, Yorks.	Bartle & Son (Dept. J), 50-52, Merrion Street, Leeds, 2. (Tel. 20988)

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ENGINEERING Impact

of Competition and Railway Standards

THE British Railways and the engineering companies who provide their locomotives and equipment have more in common than a shared interest in the future of rail transport in the United Kingdom. Competition, already fierce and becoming sharper, is constantly at the elbow of both the railways and their suppliers. For British Railways the opposition comes from the roads and the air; for the manufacturers it springs from the relationship of the world capacity to the demands of those countries with rail services which must be equipped or renewed.

The approval given by the Ministry of Transport to the British Transport Commission for the construction of a new engineering research laboratory for the railways, referred to by Mr. Ernest Marples, the Minister of Transport, at the recent lunch of the Institution of Locomotive Engineers, is relevant to both parties in the railway world.

It is intended that the organization of the BTC for research and development shall be enlarged and improved, with a corresponding increase in the number of staff. Mr. Marples said that the target was the best scientific and technical advice for the railways and an even closer relationship with the research organizations of private industry.

That this is a key step in the railways' future was made clear from the lecture given on the same day by Sir Brian Robertson, chairman of the British Transport Commission, to the Institution of Locomotive Engineers—who are this year celebrating their 50th anniversary.

Sir Brian observed that it was always possible to find arguments that conditions so varied from region to region that each must have its distinctive type of locomotive. Horses for courses was a good motto for the racing fraternity, but applied to locomotives it was a luxury which British Railways cannot afford. This meant that in the future manufacturers would inevitably have to expect "rather more detailed" specification from the railway engineers than they have had in the past.

Engine Exports

In this standardization lies one of the keys to the future conditions under which British locomotive manufacturers look like having to work. Stricter standardization should mean that cost reduction becomes more of a possibility on locomotives for use in Britain. The other side of the penny is that of exports.

British locomotive and rolling stock manufacturers have known for some years that a time was approaching when for the maintenance of their level of activity, and still more for its expansion, more and more dependence would have to be placed upon supplying the railway needs of overseas. Since it by no means follows that what the British Transport Commission decides is best for the special conditions of railway operations in the United Kingdom is in line with the requirements of South Africa, Latin America or India, the outlook is that the full cost of developing certain types of locomotives for overseas use will only be recoverable against the export orders obtained.

This is hardly a happy situation compared with the majority of exporters, whose competitive costs tend to be reached by the use of spreading the overheads across the part of their output which is swallowed up in the home market.

Suiting the System to the New Costs

ON THE subject of locomotive costs Sir Brian Robertson conceded that only in the last few years had British industry had an opportunity to carry out large-scale manufacture of high powered diesel locomotives. Now electric locomotives suitable for the 50 cycle ac system were also wanted. Under these circumstances a "rather high cost" was understandable, but with experience now accumulated, Sir Brian would like to see the manufacturers giving "very serious consideration" to reducing the cost without sacrificing one iota of quality.

At the moment the initial cost of a high powered diesel locomotive for the main line is between three and four times that of a steam locomotive of corresponding power. It has not been the experience of British Transport that they can arrange schedules to ensure that every main line locomotive does a sufficient annual mileage to justify such a price. Sir Brian will shortly be handing over to the new man, Dr. Beeching.

No one can be certain what Dr. Beeching will contribute to the railway problem; it may be new thinking derived in part from the experience of large scale private business, or it may be a new effectiveness in imparting the successful attainment of goals that are not themselves difficult to define.

High Powered Loss

One proposition suggests itself from Sir Brian's speech to the Locomotive Engineers. He observes that the schedule arrangers have not been able to get a full economic return from the high priced equipment they are now using. His remedy, at least in part, is the exhortation to the manufacturers to cut their prices.

There would be rather a cool answer to the car hire proprietor, catering to the carriage trade, who found he was not doing well and went to the maker of his luxury cars with a proposal that he should be sold them for less. His job would be either to carry more passengers, or if the business appeared to be constant (an unlikely thought) to find more economical vehicles for his fleet.

For British Railways the target seems now to be a more efficient use of its splendid main line equipment. The recent troubles are said by Sir Brian to have given the engineers concerned experience that has given them a lead in this field of engineering. In the course of their inquiries the manufacturers had unearthed new knowledge.

With this behind them the next aim is, in Mr. Marples's words, for "a railway system of the right size and shape." When the too frequent stops, the uneconomic parts of the system and the other factors that turn a diesel locomotive into a liability instead of an asset have been given some of the ruthless treatment that, for instance, the French have applied to their railways, then the morale lowering dependence on alms from the protesting taxpayer will begin to disappear. In its place a streamlined service, perhaps linking only key centres, but by very fast high-frequency expresses, whether for passengers or goods, with the more flexible, and initially less costly, commercial truck, filling in the in-between distances should then begin to win back the good name of British Railways.

of British Industry Meeting Europe's Needs

THE reports of the Export Council for Europe's Pathfinder Missions to Austria, Denmark, France, Italy, Norway, Portugal, Spain, Sweden, and Switzerland are a challenging mixture of missed chances, past neglect, present good opinions and future opportunities.

Western Europe, says the Export Council's report, presents one of the most promising markets in the world—rich, sophisticated and discriminating. And fast expanding—the hard travelling executives who formed the teams might have added.

One important overall impression brought back was of the valuable resources of goodwill towards the United Kingdom—a residual feeling that persists despite an export record which contains some significant failures, as well as some outstanding successes. Any assumption, warns the report, that goodwill is a substitute for good service would be dangerous.

Sir William McFadzean, chairman of British Insulated Callender Cables and chairman of the Export Council for Europe, and his fellow Council members repeat the well worn, but still essential principles of successful selling to Western Europe, or any other market. The manufacturers must be efficient, they must produce the right goods at the right time, and they must sell hard and provide essential after-sales service. The competitors, and in particular the West Germans, pay meticulous attention to the customers' needs, tastes, standards, delivery requirements currency and language.

Reporting that in other countries factories specializing in export production have sprung up, the Council roundly states that too much of British industry has been geared primarily to domestic needs and traditional markets. A new adjustment is needed and it is not true that time is on our side.

Price Barrier

Shades of the continuing Channel tunnel or bridge controversy appear faintly in the Council's emphatic belief that a means of by-passing the Channel "obstacle," or of surmounting it more efficiently, is a problem which demands immediate attention. Modern ferry services and air bridge techniques cut down the time lost, but still amount to a price disadvantage in a field where prices are particularly keen.

The findings of the missions, taken collectively in broad industrial groups, are based on so much careful preparatory work and detailed questions at many levels in each country that they provide a good general guide to what is possible for United Kingdom engineering in Western Europe.

In France there is a demand for heavy industry linked to her current modernization efforts; in Italy boom conditions and in Austria an upward trend in industrial production present sizeable opportunities for the export of capital goods. Both Spain and Portugal have schemes for increasing industrialization.

Conditions in Spain have been improving since the success of the stabilization plan put much greater strength into the peseta. There is now scope for the export of plant and equipment, particularly generating plant for new hydro-electric stations and diesel electric locomotives for the railway system. Over a 15 year span there are to be seven nuclear power stations built in Spain. Some of these are contracts which could go to British heavy engineering groups when the orders are being placed in 1963 and 64.

Smallness is no excuse for ignoring a market, particularly when the country concerned, in this case Portugal, had a total import bill of £196 million in 1960 (UK share only 12·7 per cent) and has reached a stage where industrialization may rise in a spectacular fashion. Portugal wants to learn more about British techniques, and the know-how can be sold there either by making or assembling capital goods on the spot. Whether this is to be done through subsidiaries or by licensing arrangements is a matter for individual decision.

Selling Ships to Norway

FROM shipbuilding there not surprisingly comes an example of why our exports have not been doing better. Back in 1950 Britain built 31 per cent of Norway's tonnage, by 1959 this percentage had dropped to only 1·8 per cent. In 1960 it had recovered a little to 4·5 per cent and it is now back to about 10 per cent.

Why? The Mission in Norway asked and were told that the fall in orders is attributed to inadequate credits. British offers had been of 5 years compared with 10 to 12 years from other countries. On prices, some quotations had been up to 12 per cent above competitors. Delivery performance by British firms had given us a poor record and in the less modern United Kingdom shipyards building periods were up to two or three times longer than in Sweden, Germany or Holland.

In general terms the Council calls for a "vigorous and cooperative effort" to increase British ship exports to Norway.

From Sweden there is reported the complaint that shipbuilding and allied interests do not seek to maintain contacts with Swedish buyers and that if replies are sent to inquiries they are deficient in technical information. This is a particularly unwise state of affairs in market where everything concerned with shipping enters duty free.

Given a vigorous sales policy there is a market for British made cargo-handling equipment in Sweden. On the other side of Europe, the Mission in Italy found, among other opportunities, a need for simply designed and low priced inboard diesel engines.

Selwood Orbital Engine

Prime movers based on new principles come along at not infrequent intervals but few succeed. The new Selwood engine described below may be destined for greater things.

A TANTALIZINGLY brief description of a new prime mover was given in a recent issue (ENGNG., 5 May '61, p. 637). More recently ENGINEERING, has seen the engine running and semi-dismantled and learnt something of its action and construction.

Feeling that the reciprocating engine has nearly reached its ultimate in development and speed, and that the gas turbine leaves much to be desired in the way of fuel consumption and flexibility, Selwood, a Hampshire engineering firm, enlisted the services of Mr. Cecil Hughes to design and collaborate in the development of a new type of prime mover.

Many other people have felt that something to replace the conventional engine is needed and a promising design to rear its head has been the Wankel engine which is still under development. The Selwood orbital engine—the exterior of which can be seen in Fig. 1—is quite different in principle.

It consists, as can be seen from Fig. 2, of three basic elements. (1) A stationary shaft, carrying on a ball bearing, a (2) spider supporting between its arms six double ended pistons, which all rotate with (3) the cylinder block and output shaft. It can be seen that the spider carrying the pistons is at an angle to the stationary shaft and rotates constantly in this plane. The six cylinders are equally spaced around the barrel-shaped split block.

Because of the angle at which the axis of the pistons is inclined they move in and out of the cylinders during the course of one revolution. Selwoods are at pains to point out that this cannot be regarded as a reciprocating motion because the pistons do not move from side to side while revolving. From Fig. 2 it can be seen that point " P " has in the course of rotating 180° moved from a position corresponding to bottom dead centre to top dead centre.

Because the pistons are not reciprocating there are no inertia forces acting on them, and with no connecting rod there are no side thrusts on the cylinder walls.

The engine runs on a two-stroke cycle and normal medium grade petrol-oil mixture is used. This enters via an SU carburettor through an annulus surrounding the stationary centre shaft and is distributed evenly round the induction ports. Some of the mixture passes through the centre of the stationary shaft to lubricate the end bearing and then passes to the combustion chamber. Exhaust ports are arranged on the periphery of the rotating cylinder block, there being three to each cylinder. On the rig as demonstrated a Root's type blower driven by the engine was installed to scavenge the exhaust gases from the cylinder.

At each end of the cylinder block there are six normal sparking plugs the tops of which during rotation pass stationary electrodes causing a spark to jump across the 0·010 in gap. There are 12 firings per rev. which occur as six pairs of simultaneous explosions. As each pair of explosions is made up of one from each bank of cylinders, end thrust on the main bearing is largely removed.

In observing the engine running at low and high speeds there was little or no vibration. In fact the rig on which it was mounted was not even bolted to the floor. Although Selwood gave no performance figures for the engine it is said to have good torque characteristics throughout its speed range. In running the engine at 3,000 rpm, which was said to be about 25 per cent of its maximum, it sounded rather like the old 1172 cc Ford side-valve engine. Bearing in mind that no silencer was fitted it was very quiet. Providing a silencer would be a simple matter of fixing an annulus with clearance for exhaust around the rotating mass.

The model shown—which is incidentally the only one in existence—has a compression ratio of 3 to 1. Selwood pointed out that the purpose of this engine was to show that the idea would work and higher ratios could come later. It may be that with higher compression ratios the cooling would need something better than relying on the mass revolving through the air. At the moment the cooling fins are at right angles to the main shafts because it was easier to turn them that way, they would however be more efficient parallel to the shaft.

Apart from minor things like easing clearances, the engine ran straight off the drawing board. No spare parts exist and during the 300 odd hours it has run, over a period of some 12 months, no replacements have been made, not even a sparking plug. This development model, having a capacity of 700 cc, approximates to a 10½ in dia sphere. A mock-up of an 8 litre model was in the workshop and was 21 in in diameter. The development model was machined from the solid. *William R. Selwood, Chandler's Ford, Hants.*

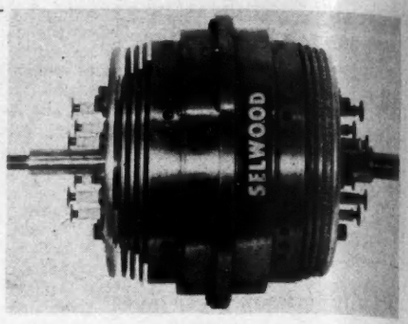


Fig. 1 The engine in its assembled form.

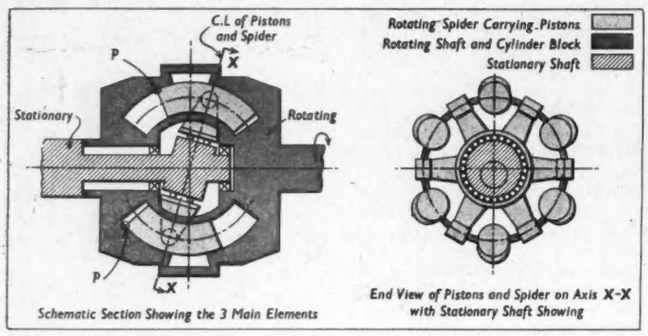


Fig. 2 (Above) The pistons and the cylinders rotate in different planes.

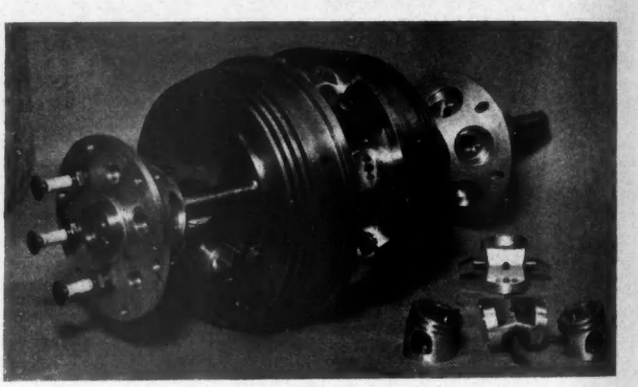


Fig. 4 (Above) The three-part piston can be seen. The engine is viewed from the fuel inlet end.

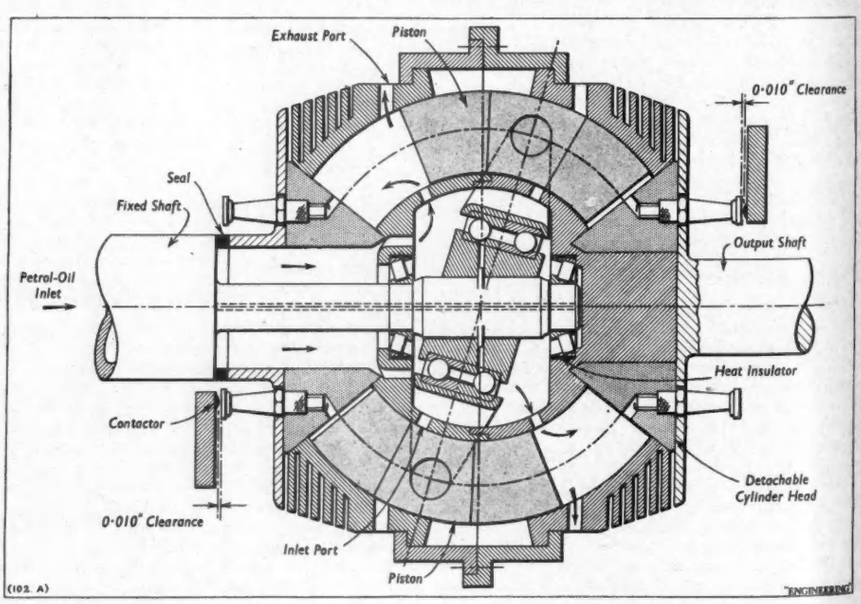
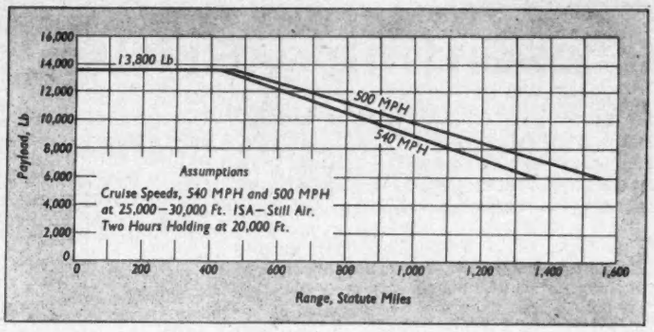


Fig. 3 (Below) A section through the engine which shows the components in more detail.



The BAC One-Eleven can carry its full complement of 57 mixed passengers and baggage at 500 mph up to 800 miles or 43 passengers for 1,200 miles.

BAC One-Eleven: Jet Successor to the Viscount

One of the key aims behind the new BAC One-Eleven has been to produce a short haul jet which has economics better than the Viscount turbo-prop airliner.

Few people would disagree that the Vickers Viscount has been the most successful post-war British civil aircraft, over 400 of them having been sold to more than 50 operators. Thus any airliner which is intended to replace it must be a worthy successor. First airline deliveries of the BAC One-Eleven are scheduled for the autumn of 1964 when some Viscounts will be due for replacement.

This is what the British United Airways have in mind in placing an initial order for ten, with an option on five more subject to receiving a licence from the Air Transport Licensing Board to operate new routes. Their confidence in the One-Eleven is endorsed by several American and Continental operators who are making firm inquiries about the aircraft.

Having been conceived from the start as a rugged, reliable "airlines aircraft," special attention has been paid to a high standard of equipment and to the quick turn-round essential in short-haul operation. As an example of this, an auxiliary power unit will be standard, giving the aircraft ground conditioning and self-starting thus dispensing with special equipment based at every airport on the airline's route. In thus reducing station costs, the aircraft's economics are improved. To meet the exacting demands of short-range high-frequency operation, the design places special emphasis on straightforward handling characteristics and low approach speeds.

While the One-Eleven is the first civil aircraft to be designed and planned by the aircraft team of the British Aircraft Corporation, much of its inspiration obviously springs from the Vickers camp. Appearing somewhat like a twin-engined version of the VC10—although the wings are not swept back so much—it does in fact use the Vanguard and VC10 type wing panels machined from the solid and employing the fail-safe design philosophy. This is based on low stress levels and multi-load paths, so that the failure of one structural element will not be disastrous.

With an overall wing span and length of 88 ft 6 in and 93 ft 8 in respectively, the One-Eleven follows the modern trend of having its engines mounted at the rear. This layout has among other advantages those of safety and efficiency and because the wings are left clean they provide greater lift which in turn will give the aircraft its good landing and take-off capabilities. Noise within the cabins will be even less than that experienced in the Viscount. From the ground, the makers say that the aircraft's noise level at take-off will be less than that of the present jets and what noise there is will be short lived as the aircraft has a rapid rate of climb.

Rolls-Royce Spey by-pass engines are specified as the power units. This engine is the latest in the RR family of by-pass jets and has been running since December 1960. The Spey is of twin spool configuration; the air flow from the low pressure compressor being split equally between the by-pass duct and the high pressure compressor feeding the combustion system and turbines. The two flows then merge to be expanded through a common exhaust nozzle. Initial rating for the Spey is 9,850 lb minimum thrust at sea level. It has been designed for low fuel consumption, low maintenance costs and long life between overhauls.

The engines give the One-Eleven a maximum cruising speed of 540 mph, but 500 mph produces maximum economy and an extended range. Normal cruising altitude will be between 20,000 and 30,000 ft. Pressure differential is given as 7 lb per sq. in. Full passenger complement with baggage is 57 at 500 mph for stages of 800 statute miles with 2 hours reserve. It can alternatively carry 43 passengers for 1,200 miles—similar to the Viscount 800—or on shorter hauls of up to 450 miles, 69 tourist passengers and baggage or 57 passengers and over a ton of freight.

A lighter version, the 107, will follow about a year later.

British Aircraft Corporation Limited, 100 Pall Mall, London SW1.

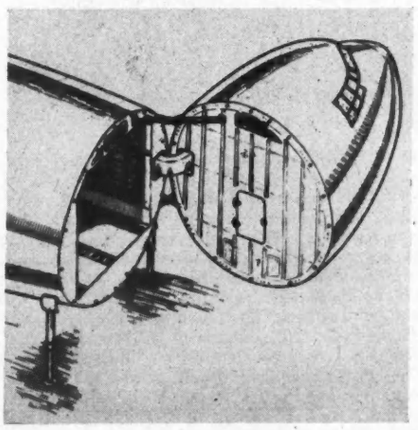
Swing-Nose and Twin Decks for Aircraft Transport

A new swing-nose two-deck version of the Short SC 5 Belfast civil freighter for long haul cargo and passenger transport has recently been announced.

Aimed at the rich North Atlantic cargo traffic, the new Belfast is intended to carry payloads of up to 100,000 lb non-stop between New York and London. Short's believe that an aircraft designed for specialized container traffic will be more effective with a swinging nose, since this allows the full volume of the aircraft to be loaded in one operation.

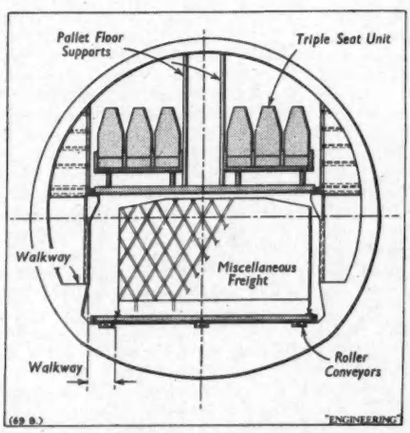
Investigations carried out by the company have led them to come to two conclusions about cargo systems: (*a*) container or palletized loads must not be too high if they are to be manageable at loading centres, and (*b*) that the carriage of passengers and freight in the same aircraft must be catered for. They believe the optimum height whether built up or on a pallet or loaded inside a container is about 6 ft.

These factors give rise to the new version of the SC 5 being provided with two floors. The main or lower floor is of very light construction and carries three rollerways for pallet loading. On the sides of the fuselage about 6 ft up are two longitudinal lines of rollers with which the second layer could be inserted in the form of another series of pallets or cage-like containers.



With this arrangement, the aircraft can carry 55,000 lb of freight on the lower floor with 138 passengers and full amenities on the upper floor, or 100,000 lb of freight with 60,000 lb on the lower and 40,000 lb on the upper.

Short Brothers and Harland Limited, Aircraft Division, Queen's Island, Belfast.



The swing-nose two deck version of the Short SC 5 freighter is the result of intensive studies by the company to find a new approach to cargo systems. The nose portion can be seen swung open (on the left) and a typical section through the freighter is seen on the right. The two decks give flexibility in cargo and passenger capacity.

Presenting British Aircraft in Paris

In showing at the Paris International Airshow at Le Bourget, the British aircraft industry is making its biggest-ever effort at any overseas display.

THE Short SC 1 VTOL aircraft has recently taken-off vertically from a flat unprepared concrete surface; hitherto a special platform had been used. Now for the first time, at the Paris show, the SC 1 will display its impressive performance as it hovers above Le Bourget airport. Models showing the possible future development of such craft will be displayed. The same company will also have models of their Belfast and Skyvan freighter. Shorts recently gave the news that the Belfast would be available in a swing-nose twin-deck version and this is described on the previous page.

Although the Continent has its own light and executive aircraft, there will be widespread interest in the new Beagle-Austers which have only just had their first public showing in this country. The A109 Airedale will be there in person, but its partner, the Terrier will be represented by model only.

The four-seater Airedale has a car-type interior with front and rear doors and separate baggage door. It conforms to modern practice with its spatted, tricycle undercarriage with steerable nosewheel. Powered by a 180 bhp Lycoming

Beagle-Auster A109 Airedale for executive flying.

engine it has a cruising speed of more than 140 mph and an endurance of 7·6 hours. Provision is made for the installation of all-weather day and night flying instrumentation. Making wide use of glass reinforced plastic, the Airedale is constructed to the latest standards of aeronautical thinking.

The Terrier, a two/three seater, has a 145 bhp dH Gipsy Major 10 engine which gives it a cruising speed of 110 mph. One of its features is the attention paid to reducing the noise level both inside and outside of the aircraft. A long extended exhaust pipe with silencer contributes to this and it is said by the makers that the Terrier is one of the quietest aeroplanes now flying. This is a particularly useful point as the plane is also intended for training purposes, when constant circuiting of an aerodrome is all too well known to nearby residents.

These two aircraft mark the start of the Beagle range, which it is intended to extend to twin-engined planes.

Perhaps the most satisfactory aspect of defence policy over the past year has been that a strong emphasis has been placed on air mobility. Orders were placed by the services for 36 Armstrong Whitworth Argosies, 5 dH Comet 4C's and 10 Short Belfasts. In addition it has been revealed that the RAF will take delivery of 5 Argosies, 17 Whirlwinds and 9 Belvederes between April 1961 and March 1962.

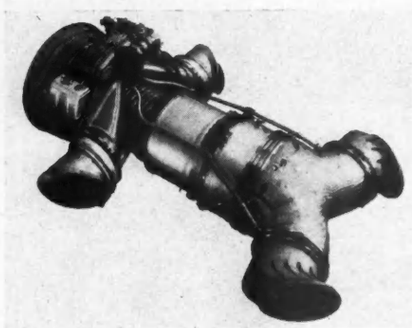
The military version of the Argosy designated the C Mk. 1 by the RAF will be shown at Paris in the colours of Transport Command. Powered by Rolls-Royce Dart turboprops, it made its first flight during March of this year. Hawker Siddeley Aviation are also taking the Avro 748 40/44 seat airliner overseas for the first time. This aircraft showed to those at last year's Farnborough show its remarkable landing and take-off performance. It has in fact been designed to operate from airfields of limited runway length and is specially suited to operation from airports at high altitude and in conditions of high temperature. Low pressure twin tyres enable the 748 to take-off and land on semi-prepared surfaces.

From the other side of the Atlantic, de Havilland (Canada) are showing their Caribou. Capable of carrying 32 troops or 7,840 lb of cargo when operating from short improvised landing strips, it can take-off and clear a 50 ft obstacle (zero wind) in just over a thousand feet, and land in the same distance. Other items on view in the Hawker Siddeley group will be models of the dH 125 executive jet, the P1127 VTOL fighter and the dH Trident airliner.

Westland Aircraft, the largest constructors of

The Avro 748 goes overseas for the first time.

helicopters in Europe, are presenting four helicopters and the Rotodyne. The latter, since it last visited the continent has completed considerably more flying hours and several additions have been built into the machine including a rotor head fairing and a central fin. Among the helicopters which Westland are showing (all of which are in current production) is the 5/6 seat Scout. Powered by a Blackburn Nimbus free-turbine engine, it is on order for



Bristol Siddeley Pegasus engine for VTOL aircraft.

the British Army. It is fitted with power controls and is fully equipped for day or night operations in all weather conditions. Having taken over the SR N2 Hovercraft, Westlands are displaying a model of it in the static section of the show. For many Continentals this will be the first time they have seen anything of a Hovercraft in three-dimensional form.

Many power plants will be exhibited including the Bristol Siddeley BS 53 Pegasus lift-thrust engine. Selected for the Hawker P 1127 VTOL strike fighter, the BS 53 has an exceptionally high take-off thrust in relation to its cruising thrust and the specific fuel consumption at cruising thrust is low. The most revolutionary feature of the engine is the use of movable jet nozzles, by which the whole of the thrust can be directed downwards for lift, backwards for thrust, forward for braking or in any intermediate direction. This makes possible the design of both single and

Now hovering over French soil, the Short SC1.

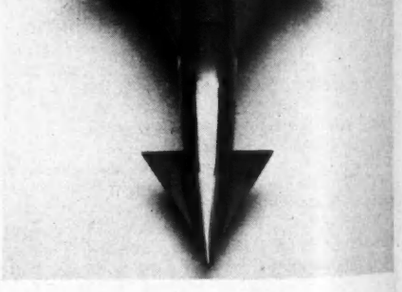
multi-engined VTOL aircraft in which all the engines are of the same type and the whole installed thrust is available for vertical take-off.

The BS 53 is a two-shaft engine in which the fan and high pressure compressor rotate in opposite directions, so that there is little resultant gyroscopic couple. The hp compressor, its turbine and flame tubes are based on principles already proved in service.

Other engines for VTOL aircraft are the Rolls-Royce RB 108 lightweight-lift engines, two of which are mounted side by side and the more powerful RB 145.

News from France itself of a supersonic version of the Caravelle airliner will be received with interest. The present Caravelle set the trend of aircraft with the engines at the rear and if the new version is as successful as its present day brother it should be well received. Reports suggest that the Super-Caravelle, which will fly at more than Mach 2 and will be ready for regular service in 1967-8, is intended for transcontinental routes. Carrying 70 passengers, it will be smaller than the present version.

The industry's export drive is not only being supported by the showing of civil and military aircraft but by missiles as well. A ground-to-ground missile which may be adopted by NATO is the British Aircraft Corporation's Blue Water. Intended for army use it is described as advanced and highly mobile, and this will be its first appearance.



Short's model of a VTOL light strike aircraft.

Plain Words

By Capricorn

BAD news makes better news than good news, or so it seems from glancing at the headlines. Scandal or disaster, suffering or sin catch the public interest; while happiness, success, virtue and enterprise are lucky if they reach the inside pages. However does the poor PRO make a living?

How can he create a healthy image for the firm he represents if his client is only news when his factory burns down, his men go out on strike, or his product is involved in an accident. But there is one thing worse than a good press and that is to figure frequently in government reports.

I see that the shipbuilding industry has been the subject of another document. True, in this case the report has come from within the industry itself, but once again it is concerned with the ills of the industry. There have been several such reports over the last year or so. Indeed shipbuilding has probably now joined the distinguished company of "industries which have been reported on more than any others." Existing members of the club are machine tools, cotton textiles and coal. To be eligible is not necessarily to be failing the public, but rather to have become, perhaps through misadventure, a public target. The steel industry was once a member too but perhaps its membership, after years of operating at high levels of output and excellent publicity, has lapsed into the honorary sort.

If anyone were to ask me how do I know when an industry has fallen on hard times I would say: when it becomes the subject of numerous reports. This is a much more tell-tale indicator in these days of full employment and government subsidies than low employment and weak prices.

Let an industry have a persistent run of bad times in this articulate age of arm-chair diagnosticians and a spate of analyses and prescriptions will follow. There will be government inquiries, pamphlets by research organizations, articles in the learned journals, more articles in not-so-learned journals and a series of broadsides from the industry itself, saying first of all that the critics are too pessimistic and also that there are those about who have an axe to grind. There are some industries, which shall be nameless, who have had so much paper covered with their troubles and so many advisory bodies set up to solve their problems that they might as well be nationalized and done with it.

But so far as I know, few if any of these industries have been propelled out of their difficulties by the wordage which has been devoted to them. There is a library on the cotton industry—which is still in trouble. Far be it from me to suggest that there is no power in the printed word but it was never a substitute for enterprising management and vigorous decisions.

No news is good news, in more ways than one, and, as I discovered in my schooldays, we could manage very well without reports.

Letters to the Editor

Sub-Critical Assemblies

SIR, I have read your interesting Atomic Review article on "Neutron Exploration" (ENGNG., 7 April '61, p. 487).

Subsequently, Mr. K. S. Burgess wrote claiming that the article was misleading (5 May '61, p. 620). In fact, Mr. Burgess has given an inaccurate statement of the position of S.A.M.E.S. (Great Britain) Limited.

Miles Hivolt Limited are the selling agents for SAMES electrostatic generators, particle accelerators and neutron generators. Their position is quite unaffected by the setting up of our company.

Our company acts as a technical consulting organization covering the whole range of activities of SAMES.

Also, our company are very actively concerned with the nuclear field. The sub-critical reactor "Uranie II" is marketed by us in the United Kingdom. Miles Hivolt Limited market their own sub-critical reactors.

Yours faithfully,
A. W. BRIGHT,
Director.

S.A.M.E.S. (Great Britain) Limited,
London, NW10.
10 May, 1961.

Scale Models for Hydraulic Investigations

SIR, May I refer to your Research Report article entitled "Wider Use of Hydraulic Investigations" (ENGNG., 31 Mar. '61, p. 470), and particularly to details of the model of Salaverry Harbour, Peru, which involved sediment movement? Scales of 1:200 horizontal and 1:75 vertical were used.

It is stated that "in the case of mobile bed studies, the slopes and velocities resulting from the use of an undistorted model are usually too small to simulate prototype movements. The solution is the adoption of an exaggerated vertical scale." Such comparisons of wave action with stream flow conditions are likely to lead to misconceptions.

For example, the main effect of distortion in open channel models is to provide a greater bed slope which, in turn, supplies more energy to the stream. This results in higher velocities which effect a larger bed movement. Waves, on the other hand, contain energy in the form of wave height and wave period and cannot be distorted in the model unless the original characteristics are discarded.

The wave motion, particularly in shallow water, is controlled by the depth and is, therefore, determined by the vertical scale. The effect of reducing the horizontal scale is to steepen the ocean floor and, hence, the sediment must be swept up a steeper slope than in the prototype. Because of this it is preferable to have undistorted models where waves are moving sediment, but this would generally result in oversized models.

It might be noted that, where reflection from a marine structure may influence the wave motion and, hence, the sediment movement, the surfaces of these structures should not be distorted. For example, the exposed face of a breakwater should have the same slope in the model as in the prototype even though the ocean floor is to a distorted scale. To maintain the same overall width of breakwater the unexposed face may have to be vertical.

Another aspect of the Salaverry model on which I should like to comment is that of the fly ash used for the sedimentary material. It was reported that this moved readily even with small waves.

It is generally accepted that a time scale cannot be attached to sediment movement even in stream flow situations. With wave action many more variables enter the picture, such as wave characteristics over an annual climatic cycle and rates of sediment movement both inside and outside the breaker zone. These difficulties will not be enlarged on here, but they are very real and require drastic simplification of the prototype data, in all its scarcity.

This problem is overcome somewhat by the fact that any wave is satisfactory in a model for moving sediment so long as its period is sufficient for it to affect the ocean bed to the correct depth. Its height need be sufficient only to move the sediment used, which can be just slightly finer than that in the prototype. Only ultimate trends can be studied and a wide range of wave and sediment characteristics will present the same result at different speeds.

The only point to watch is that the mode of movement in the model is the same as that in the prototype. Thus, if the motion is by bed load in nature it must not be suspended load in the model, because this may result in erroneous accretion and erosion patterns.

Yours faithfully,
R. SILVESTER,
Senior Lecturer in Civil Engineering.
The University of Western Australia,
Nedlands,
Western Australia.
12 May, 1961.

Events in Advance

Building and Public Works Exhibition

PROMPTED by the success which has attended previous exhibitions arranged by the Advertising Publications Company Limited, this firm are organizing an exhibition in the south west of England to be devoted to public works and the building industry.

This event will be the first exhibition of its kind to be held in that area for a number of years. It will be known as the Building and Public Works Exhibition, will be supported by the South Western Federation of Building Trades Employers, and is being held at Whitchurch Air Field, Bristol, from 13 to 23 June, 1962. The site that has been selected is that used for the Royal Agricultural Show, well known as the Exhibition Venue, and is very accessible from all parts of the area.

The organizers intend that every aspect of the building and associated industries shall be covered, ranging from the manufacture of the smallest fitments to the construction of the largest types of contractors' equipment.

Requests for additional information, applications for space, etc., should be addressed to the official organizer: Mr. J. Sandler, Advertising Publications Company Limited, 20 John Street, Sunderland. Telephone: Sunderland 71464.

Civilian Aspects of Space Technology

APPLICATIONS of space technology in the civilian field, especially in connection with such matters as communications and meteorological satellites, are among the subjects which will be considered at the European Symposium on Space Technology which is being organized by the British Interplanetary Society and which will be held at the offices of the Federation of British Industries, 21 Tothill Street, London, SW1, from 26 to 28 June next.

Another main purpose of the meeting will be to draw attention to future trends in the development of space flight and, in particular, to review the future possibilities relating to West European capabilities, taking into account advanced studies which need not call for very considerable budgets such, for example, as structural and propulsion problems, and control engineering.

In addition, a number of discussion papers will be presented dealing with the effects of space technology on the present structure and level of

industry, especially those of an international character and taking into account the political and economic aspects. The third day of the meeting will be devoted to the consideration of these discussion papers.

It is intended that there shall be some departure on this occasion from the normal procedure adopted at technical symposia, in that opportunities will be given to promote discussions, pose problems, and ascertain to some extent the probable lines of development in international politics and industrial collaboration needed to set up a basic structure in space technology for West European nations. In addition, the symposium is being convened in the hope that the realization that a new surge of technical progress is gathering momentum may become more generally understood and appreciated.

Altogether, arrangements have so far been completed for the presentation of some 20 papers and preprints of all papers relating to future trends in the development of space flight and to applications of space technology in the civilian field are expected to be available about one week before the meeting opens. Synopses only will be read of the discussion papers dealing with the effects of space technology on the structure and level of industry, as it is intended that the greater part of the last day shall be concerned with the general discussion of the ideas put forward.

In view of the international character of the proceedings, the organizers are providing simultaneous translation facilities in English, French and German. Further information is obtainable from Mr. L. J. Carter, secretary, British Interplanetary Society, 12 Bessborough Gardens, London, SW1. Telephone: TATe Gallery 9371.

Atomic Gathering in Chicago

AN ATTENDANCE of some ten thousand nuclear scientists, engineers, industrial leaders and educationalists is expected at this year's annual winter meeting of the American Nuclear Society, which is due to be held at the Conrad Hilton Hotel, Chicago, from 6 to 9 November. The unusually high attendance expected on this occasion is in some measure due to the fact that the coming meeting has been arranged in conjunction with the Atomic Industrial Forum and the Atom Fair.

The preliminary preparation of the technical programme for the Society's winter meeting is now well under way and technical contributions on all aspects of atomic energy are being invited from both members and non-members. Persons and organizations who would like to present papers for consideration are asked to submit their manuscripts not later than 4 August next direct to Dr. H. O. Monson, the chairman of the Society's technical programme committee. His address is Argonne National Laboratory, 9700 South Cass Avenue, Argonne, Illinois, USA.

Mr. John L. Kuranz, vice-president of the Nuclear-Chicago Corporation, has been appointed general chairman of the Society's winter meeting, and Dr. Warren C. Johnson, vice-president of the University of Chicago, as the honorary chairman. Further particulars may be obtained from Mr. Octave J. Du Temple, executive secretary, American Nuclear Society, 86 East Randolph Street, Chicago 1, Illinois, USA.

Statisticians to Meet in Bristol

THIS year's joint conference of the Industrial Applications and Research Sections of the Royal Statistical Society will be held in the Churchill Hall of the University of Bristol during the weekend 9 to 11 September.

The complete programme is still to be arranged but a number of papers on industrial aspects of statistical research have been promised and further details of the conference will be circulated to those interested very shortly. The fee for the conference is £1 10*s* and for accommodation and meals for the duration of the meeting an additional 4 guineas.

Accommodation is limited and early registration is desired. Communications should be addressed to Mrs. P. Arakie, Department of Operational Research and Cybernetics, United Steel Companies Limited, 1 Tapton House Road, Sheffield 10. The Society's address is 21 Bentinck Street, London, W1. (Telephone: WELbeck 7638.)

Exhibitions and Conferences

Arranged in chronological order

Whole Body Counting, Symposium (Effects of Radiation).—Tues., 13 June, to Fri., 16 June, 1961, in Vienna. Apply to the International Atomic Energy Agency, Kaerntnerring, Vienna 1, Austria.

Aerospace Sciences, Combined National Technical Meeting on.—Tues., 13 June, to Fri., 16 June, 1961, at the Hotel Ambassador, Los Angeles, California, USA. Organised jointly by the American Rocket Society; and the Institute of Aerospace Sciences, 2 East 64th Street, New York 21, USA.

Building and Public Works Exhibition.—Wed., 14 June, to Sat., 24 June, 1961, at Castle Bromwich, Birmingham. Supported by the Midland Federation of Building Trades Employers. Official organiser: Mr. J. Sandler, 20 John Street, Sunderland. Tel. Sunderland 58939.

Constructional Equipment Exhibition, International.—Thurs., 15 June, to Sat., 24 June, 1961, at the Crystal Palace, London, SE19. Organised by the Construction Equipment Exhibitions Ltd., Drury House, Russell Street, London, WC2. Tel. TEMple Bar 3422.

Nuclear and Electronic Congress and Exhibition, Eighth.—Thurs., 15 June, to Thurs., 29 June, 1961, in Rome. Applications in the United Kingdom should be made to Fairs and Exhibitions Ltd., 2 Dunraven Street, Park Lane, London, W1. Tel. HYDe Park 5421.

Plastics Exhibition, International (EUROPLASTICA).—Fri., 16 June, to Sun., 25 June, 1961, at Ghent. Under the patronage of the Belgian Government. Organised, in collaboration with the Belgian Federation of Chemical Industries, the Federation of Manufacturers of the Metal Goods Industry (FABRIMETAL) and the Belgian Plastics Syndicate by Europlastica, Palais des Floralies, Ghent, Belgium. United Kingdom agent: Mr. Neven du Mont, 123 Pall Mall, London, SW1. Tel. WHItehall 8211.

Education and Training in the Plastics Industry, Conference.—Mon. and Tues., 19 and 20 June, 1961, at the Institution of Electrical Engineers, Savoy Place, Victoria Embankment, London, WC2. Organised by the Plastics Institute, 6 Mandeville Place, London, W1. Tel. WELbeck 5439.

Institution of Mechanical Engineers, Summer Meeting.—Mon., 19 June, to Thurs., 22 June, in Glasgow. Offices of the Institution: 1 Birdcage Walk, St. James's Park, London, SW1. Tel. WHItehall 7476.

Laboratory Apparatus and Materials Exhibition, Second National.—Mon., 19 June, to Thurs., 22 June, in the Royal Horticultural Society's New Hall, Greycoat Street, London, SW1. Organisers: UTP Exhibitions Ltd., 9 Gough Square, Fleet Street, London, EC4. Tel. FLEet Street 3172.

Instrument Show, Sixth International.—Mon., 19 June, to Fri., 23 June, at 4 Tilney Street, London, W1. Organised by B and K Laboratories Ltd., 4 Tilney Street, Park Lane, London, W1. Tel. GROsvenor 4567.

Sewage Purification, Institute of.—Annual Conference: Mon., 19 June, to Fri., 23 June, 1961, at Brighton. Conference will mark the 60th anniversary of the founding of the Institute. Offices of the Institute: 10 Cromwell Place, South Kensington, London, SW7. Tel. KENsington 3885.

Heat Transfer, International Conference.—Mon., 19 June, to Sat., 24 June, 1961, at 7 Rue La Pérouse, Paris. Organised by the Institut Français des Combustibles et de l'Energie, 3 Rue Henri-Heine, Paris 16e.

Light Metals, Fourth International Conference on.—Tues., 20 June, to Sat., 24 June, at Leoben. Theme: "Light Metals in Light Construction, in Architecture and in Special Fields." Organised by the Montanistische Hochschule, Leoben, and the Austrian light metal industry. Apply to the secretary, Internationalen Leichtmetalltagung, Montanistische Hochschule, Leoben/Stmk., Austria.

Packaging Exhibition, International (IPACK).—Tues., 20 June, to Thurs., 29 June, 1961, in Milan. Exhibition offices: 4 Via Lanzoni, Milan, Italy.

Plastics Exhibition and Convention, International (INTERPLAS).—Wed., 21 June, to Sat., 1 July, 1961, at Olympia, London, W14. Organised by *British Plastics*, Dorset House, Stamford Street, London, SE1. Tel. WATerloo 3333.

Textile Fair, Third International (MTI).—Fri., 23 June, to Thurs., 29 June, 1961, in Paris. Agents in the United Kingdom: Trade Fairs and Promotions Ltd., Drury House, Russell Street, London, WC2. Tel. TEMple Bar 3422.

Fire-Fighting Apparatus and Safety Equipment (INTERSCHUTZ).—Fri., 23 June, to Sun., 2 July, 1961, in Cologne. In the United Kingdom apply to Mr. Neven du Mont, 123 Pall Mall, London, SW1. Tel. WHItehall 8211.

Space Technology, First European Symposium on.—Mon., 26 June, to Wed., 28 June, 1961, in London. Organised by the British Interplanetary Society, 12 Bessborough Gardens, London, SW1. Tel. TATe Gallery 9371.

Measurement Conference, International (IMEKO); and International Instrument Show.—Mon., 26 June, to Sat., 1 July, 1961, Budapest, Hungary. Applications may be made to the IMEKO Secretariat (Assistant Professor György Striker, executive secretary), P.O. Box 3, Budapest 5, Hungary. In the United Kingdom, applications should be addressed to Professor J. F. Coales, Cambridge University, Trumpington Street, Cambridge.

Large Dams, Seventh International Conference.—Mon., 26 June, to Sun., 9 July, 1961, in Rome. Organised by the International Commission on Large Dams of the World Power Conference. Apply to the secretary, British National Committee on Large Dams, 201-202 Grand Buildings, Trafalgar Square, London, WC2. Tel. WHItehall 3966.

Automation: Men and Money, Conference.—Tues., 27 June, to Fri., 30 June, 1961, at Harrogate. Organised by the British Conference on Automation and Computation, c/o the British Institute of Management, 80 Fetter Lane, London, EC4. Tel. HOLborn 3456.

Meetings and Papers

The address and telephone number of the headquarters of each institution are given at the end of this list. Meetings in the headquarters town are held there unless otherwise stated.

Chemical Society

LONDON
Reception and Conversazione. Science Museum, South Kensington, SW7. Thurs., 8 June, 6.30 p.m.

Institute of Information Scientists

LONDON
Annual General Meeting, for members only, at 6.15 p.m. "Some Thoughts on the National Science Reference Library," by Miss M. Webb, at 7.30 p.m. Swedenborg Society's Hall, 20 Bloomsbury Way, WC1. Wed., 31 May.

Institute of Marine Engineers

SHEFFIELD
"The Need for Research in Diesel Engine Development," by R. V. Hughes. North Midlands Section. British Iron and Steel Research Association Building, Hoyle Street, Sheffield. Thurs., 1 June, 7.15 p.m.

Institute of Physics and the Physical Society

LONDON
"Biophysical Applications of Non-Linear Acoustics," by Dr. W. L. Nyborg. Preceded by the Group's Annual General Meeting. Acoustics Group. Physics Department, Imperial College of Science and Technology, Prince Consort Road, South Kensington, SW7. Thurs., 8 June, 5.30 p.m.

Institution of Civil Engineers

LONDON
"Auckland Harbour Bridge: Design," by Gilbert Roberts and O. A. Kerensky; and "Auckland Harbour Bridge: Construction," by H. S. Smith and J. F. Pain. Thurs., 1 June, 5.30 p.m.

Institution of Public Health Engineers

LONDON
"The Development of Bracknell New Town with Particular Reference to Its Effect on Local Government Administration," by H. Charlesworth, at 6 p.m. Preceded by the Annual General Meeting (open to corporate members only), at 4.30 p.m. Caxton Hall, off Victoria Street, SW1. Fri., 9 June.

Women's Engineering Society

MANCHESTER
Annual General Meeting. Manchester Branch. Manchester Society of Chartered Accountants, 46 Fountain Street, Manchester 2. Wed., 7 June, 7 p.m.

Chemical Society, Burlington House, Piccadilly, London, W1. (REGent 0675)
Institute of Information Scientists. Apply to Mr. J. Farradane, Torran, Croft Road, Orpington, Kent.
Institute of Marine Engineers, Memorial Buidling, 76 Mark Lane, London, EC3. (ROYal 8493)
Institute of Physics and the Physical Society, 47 Belgrave Square, London, SW1. (BELgravia 6111)
Institution of Civil Engineers, Great George Street, London, SW1. (WHItehall 4577)
Institution of Public Health Engineers, 179–181 Vauxhall Bridge Road, London, SW1. (VICtoria 3017)
Women's Engineering Society, 25 Foubert's Place, London, W1. (GERrard 5212)

Weather Protection for Production Cars

Corrosion problems on modern, mass-produced cars are well known. Much is being done to overcome them, but the ultimate answer seems to lie in the use of plastics.

By H. C. F. Haywood

MANY car users are familiar with the minute bubbling of paint which is the usual warning that rust has broken through the protective coatings applied during manufacture of the body panels.

At the Society of Automotive Engineers International Congress, held at Detroit in January of this year, several papers dealing with this subject were read by members and their comments are reviewed in this article.

The trouble is not a new one and development engineers are constantly battling to find a perfect corrosion-free finish that can be applied to the car structure before painting. The almost universal adoption of unit chassis and body construction for mass production models has meant that complex pressings are used and constructed of comparatively thin gauge material. Obtaining strength and rigidity with these steels calls for the use of many brackets and supporting webs which in themselves form traps for moisture-retaining dirt. In winter months the increased use of salt mixed with road grit makes life more difficult for any original protective coating the body metals may have had. There is no doubt, especially for the private owner who has a big capital sum tied up in the purchase of a modern car, that one or other of the underseal treatments on the market today can go a long way to prolonging body life. In addition to guarding against corrosion, there is a lessening of road-excited body noise when these compounds are used. They are especially effective when applied to the underside of a new car before it is put into serious use.

There are several methods of providing protection against corrosion of body metals. The simplest, although not the least expensive in terms of initial cost, is the selection of an alloy that reacts with the atmosphere to form a surface compound that will provide a protective film. There are applied protective coatings which include hot-dipping in zinc or aluminium, electroplating of bumpers, wheel nave plates, radiator grilles and body ironmongery with nickel, copper, chromium or cadmium and organic coatings. These can be applied by dipping, spraying or brushing and involve compositions of alkyds, vinyls, epoxies, phenolics and acrylic systems.

In order to prevent the formation of rust caused by the reaction of iron with oxygen the iron can be alloyed with percentages of copper, chromium, nickel and molybdenum. An addition of any one of these will assist in creating a rustproof barrier. These compounds include high strength low alloy steels, alloy steels and stainless steels. Unfortunately, the very keen pricing of modern car construction makes the use of these materials too expensive for mass produced cars and in the main carbon steel is used. Exceptions occur in the expensive *haute couture* world of one-off saloons and "grand touring" sports cars, when the body is usually hand built of aluminium.

CORROSION RESEARCH

Research by technicians of the United States Steel Corporation has included the use of areas providing a great variation in atmospheric conditions. Panels of low-carbon open hearth steels similar to those used in car body construction were exposed to the weather on racks in areas ranging from New York City to the sea coast of North Carolina. In a rural locality free from industrial salts and acids carried by the air, the corrosivity factor was 33; in a New York industrial site this was raised to 87 and a maximum of 666 was reached near the ocean at Kure beach, North Carolina.

Rust which forms on carbon steel is porous, adheres loosely and is voluminous in nature. If the body paint gets scratched any rust which may have formed will quickly undercut and lift the paint film. On the other hand, rust on high-strength low-alloy steel is fine in texture and clings strongly to the steel. By including quantities of chromium, nickel and molybdenum in carbon steel it can be given corrosion resisting qualities. A chromium concentration of 12 to 14 per cent will effectively provide these.

In addition to using the most economical corrosion proof steel, three other methods are being employed to combat corrosion. The chassis portion of the body structure has sections which by nature of their manufactured shape form natural traps for dirt and moisture and these methods are used to protect these parts in particular. By a combination of spraying and tank immersion of the whole body structure in a water-based primer it is possible to adequately coat, before final painting, all the areas which are inaccessible to spraying. In this way deeply recessed webs and fillets where moisture could collect are given full protection.

In some cases hot-dipped galvanized steel sheet, with zinc coatings of the same thickness on both sides or with a smooth thin film on one side and a thicker coat on the other, are used. The side with the heavier covering of zinc is used to form the interior walls of box sections of the chassis floor. A third method is to use paints which have a zinc-rich quality. Developed during the Second World War for marine use, this type of paint has been found to have superior corrosion resistant qualities.

Paints have been developed to reconcile the demands of good initial appearance and low cost corrosion protection.

The search for corrosion resistant body steels brought in further problems on the construction lines. Body assembly is mostly done in multiple welding fixtures which permit many welds in one operation. In such fixtures, welding current and electrode force are usually limited because of lack of space. Also, as the nature of the fixture is extremely complicated due to the multiplicity of welding guns, accessibility of the electrodes is difficult and electrode life is thereby very important. The zinc and aluminium coating on the steel adheres to the electrodes and can result in faulty welds. The use of steel sheet galvanized on one side only has assisted in lessening the problem.

In addition the nature of spot welding compels the use of lapped joints with consequent crevices which can form moisture traps. Arc welding gets over this, but is difficult to apply to the thin gauge steels employed in quantity production and it is also limited to slow manual operations which do not fit in with output requirements.

GLUED JOINTS

An interesting theory is put forward by Herbert D. Van Sciver of the Budd Company of Philadelphia. This is the use of adhesives to replace spot welding. Adhesives are now obtainable that will stick practically any material to another. In automobile construction there has always been a natural reluctance to combine aluminium and steel because of the dangers of corrosion caused by electrolytic action. In any case they are not compatible for welding to one another. Bonding with a suitable adhesive would overcome this and advantage could be taken of the merits of both products.

The joints of the structure units can be provided with a lap as for spot welding but if an adhesive is used, no moisture retaining crevice is formed as the adhesive would completely fill the lap. There would be many problems to overcome before adhesives could take the place of the welding gun on the production line.

Cleanliness, not seen in many assembly shops, is essential. The panels to be bonded must fit over the entire surface of both faces and some form of clamp or jig would be necessary to hold the structure together while the bond was forming. Time would be a great factor to overcome, as most adhesives require either time or heat to obtain strength and before final assembly body components receive considerable handling.

Assembly fixtures have been developed which incorporate induction heating coils so that while the units are held together the adhesive is cured. The time factor is said to be a matter of seconds using temperatures of only 350° F. By this method it is not necessary to cure the entire joint but only to provide strength for the assembly to be handled. Paint-oven temperature and the use of self-cure resins would complete the joint.

PLASTICS

While research work on steel body corrosion proceeds, investigation into the use of glass fibres, polyester resins and plastics for automobile coachwork is advancing. Very few manufacturers have embarked on large production projects with polyester resin. The Jensen 541 is one of the best examples of this type of body; it has an excellent finish being free from blemish in all respects. The Daimler SP250 has a polyester resin body structure on a separate chassis. The Lotus Elite embodies a clever design whereby anchor points for suspension, engine mounting brackets and other securing points are moulded into the polyester resin hull of the body. In America, the Chevrolet Corvette is alone with this method of construction, except for, as in other parts of the world, cars which can be termed one-off specials.

The two-seater body of the 2½ litre Daimler SP250 is in moulded polyester resin and is mounted on a separate chassis. Plastics are one answer to the body-corrosion problem.

It is a material that works happily with metal of any kind and so can be used for component parts. The roof of the Citroen DS19, heating duct of the Chevrolet Corvair, instrument panels, bonnet and luggage locker tops are only a few applications.

It is completely resistant to corrosion, it can be impregnated with colour, has a high strength to weight ratio and good sound, heat and electrical insulation properties. In the event of accident damage, the high impact strength and shock absorbing properties tend to minimize damage which in the car of a conventional metal body could be the cause of considerable expense.

Glass fibre body construction on mass production lines, similar to those at present in use, would bring in its wake an attendant problem, what to do with the sheet steel now being used. At least the corrosion worries would be solved.

The New Library of Science and Invention

With the greatly increasing volume of world technical literature, the creation of a new information library system in the United Kingdom is an urgently needed improvement in communications for industry.

By Professor R. S. Hutton, M.A., D.Sc.

It is welcome news that the Government has decided to establish both a National Reference Library of Science and Invention and a National Lending Library of Science and Technology. To compare favourably with corresponding libraries in other countries, these collections will have to be far greater than anything we have hitherto known in this country.

Both libraries can rely on large older-established collections. The Lending Library, which is administered by the Department of Scientific and Industrial Research, has made a good start under Dr. D. J. Urquhart.[1] Situated at Boston Spa in Yorkshire, it takes over some of the collections of the Science Museum Library in London. As a token of its up-to-date outlook it is acquiring an important collection of Russian literature.

The Reference Library will be based on the Patent Office Library, established over 100 years ago, and will be located in a new building on the south bank of the Thames, expected to be opened in late 1965.[2] It will be under British Museum Library control, and steps are being taken to enable it to put at readers' disposal the large collection of scientific books and journals already in the British Museum. This library, with its traditional open-shelf access, brings its readers promptly in touch with its books, and with its periodicals, which now number about 8,000, and enables visitors to get to know many publications beyond those they came to consult.

DISTRIBUTION SYSTEM

Library collections alone will not satisfy our ultimate needs, however well classified and catalogued. A distributing system must be evolved which, based on these collections, will make analysed and indexed reports promptly available to those who require them. It is here that Aslib could help, for its experience falls clearly within this province and its membership, so widely covering our industries, is directly concerned with the improved services to which this article refers.[3] The information and liaison officers of the research associations are also concerned in bridging this supply line.

The coverage of our abstract journals could be greatly increased by prompt issue of a suitable, perhaps slightly annotated, index of the existence of articles in journals which they do not themselves normally survey.

A good example is the monthly Bulletin of the British Non-Ferrous Metals Research Association, which generally reports articles a few weeks after publication, whereas one may have to wait several months for an abstract.

It is vital that one or both of these library collections, and the indexes based thereon, should be as comprehensively world-wide as possible, and include not only articles appearing in scientific and technical journals, but British and foreign patents and University dissertations (which are valuable as indicating the trend of advance) and news in the world's trade literature.

The latest information from Russia and the United States shows that each is now publishing, in several specialized abstract journals, a total of about 600,000 items per annum.[4] In neither country do those in control of the seservices consider that they have yet reached a complete coverage of the whole of scientific and technological literature. This is obvious from the review made nearly 30 years ago by Dr. S. C. Bradford and E. Lancaster Jones of the Science Museum Library, who estimated that then three-quarters of a million articles appeared each year in about 15,000 of the more important scientific journals. Today, one can safely assume that the total must far exceed 1 million.

Probably few realize the steady increase during this century in the output of scientific literature. J. J. Thomson, in a Presidential Address to Aslib in September, 1929, pointed out that "in 1877 it was perfectly easy for a professor of physics to read and even to possess all that was written on that subject. Now things have changed. I counted up only a year ago the number of papers in subjects which I ought to have read that had been published in the year. As far as I could find out they came to 5,680 and the cry is 'still they come.' One gets snowed under, almost literally snowed under, for every post discharges pamphlets, and they accumulate in hundreds."

This startling picture is confirmed by the Royal Society Catalogue of Scientific papers 1800-1900 which records an annual average of about 3,100 papers in all branches of science for the first half of the 19th century and up to about 23,000 at its end. The subsequent International Catalogue of Scientific Literature, 1901-1913, noted a maximum in 1910 of 85,519 papers. The growth has been even more rapid in recent years.

The *World List of Scientific Periodicals* in its first issue in 1924 recorded 25,000 current journals; the second edition in 1934, 38,000; and the third edition in 1952, over 50,000. The increase still continues, for the USA Library of Congress reported that about 1,200 new journals in science and engineering started in 1958.

The American Chemical Society reports a growth of chemical abstracts during the past ten years at 9·1 per cent mean average compound interest per annum, and no doubt other branches of science and technology could show similar rates of growth.

TODAY'S OUTPOURINGS

While we have failed to recognize the national importance for the application of science to our industrial development of such world-wide surveys of the literature, other countries have forged ahead. Germany, in pre-war days, probably led the world; and since then the USA has greatly strengthened its collections of foreign books and periodicals.

In 1953 Russia started *Viniti*, the All-Union Institute of Scientific and Technical Information, with a far more comprehensive collection of the world's literature than, probably, could be found anywhere else. Moreover, these Russian collections have been used most actively to provide through some 13 abstract journals an "express information service" in 48 sections, not only for the aid of the Soviet's scientific institutions but, above all, to spur on industry to modernize and develop its production. Based on these reports on foreign, scientific and technological advances, the Russians have carried out intensive propaganda in the industries themselves, to draw attention to these matters; and each plant is said to have a "department of technical innovations and developments." It is obviously important to consider how best such literature can be made available in our own country.

The researcher in most cases needs to review past work before starting on a new investigation. Industry needs still more to keep itself informed of new developments for strengthening its competitive position.

For the scientist, there is always a risk that too much time and attention given to surveying past work may stultify his capacity for original thought. As will be seen later, this calls for a division of responsibility so that the researcher can be aided by much of the preliminary survey being carried out for him. Even more is this assistance important to those in charge of industrial developments.

INDEXING AND COMMUNICATION

The experience of the Royal Society in the preparation of the International Catalogue of Scientific Literature 1900-1913, which led to a serious financial loss, showed how dangerous it is to depend on foreign cooperation in editing. It is obviously much easier to control such an undertaking with close coordination, and the International Conference of Scientific Information held in 1958 dealt fully with this question[5]. Ideally, as the Russians have shown, all the publications to be reviewed should be assembled and the abstracting arranged under one roof.

It has already been suggested that for this more comprehensive review of the world's scientific and technical literature, we need to relieve many who hold leading positions in scientific research, and in industry, of the task of surveying all this material; and that consequently we must look to improved methods of division of responsibility. Librarians of several grades and skills are already well known. More recently industry has established a new profession of Information Officers, and these no doubt are already acquiring skills in discovering short cuts for drawing the attention of those concerned to some news item of outstanding importance.

It is surely by the provision of the service of liaison officers in libraries and industry that better use can be made of the world's published information. I have dealt with this question fully elsewhere, pointing out the importance of concentrating the attention of business executives on the really important items of news resulting from such and documentation surveys[6].

There are no doubt many scientists and industrialists who discount the importance of a comprehensive survey of this vast outpouring of publications. It is, of course, true that much duplication exists and that much is of relatively low grade quality. It would be possible in the proposed indexes and abstracts to indicate the character of the original article by using hieroglyphics to distinguish between really new contributions, reviews, and re-hashed copies of some prior publication.[7] On the other hand, the scatter of these publications throughout 50,000 or more journals is such that often matters of importance are missed. Mendel's classical papers on genetics, which were overlooked for 30 years, are an example. For industry one could quote many cases where manufacturing methods or products have been in use for a very long time abroad before being known in this country. As a matter of fact, it is often from the less well-known journals that important technical information can be gained.

REFERENCES

[1] D. J. Urquhart. Library Association Scarborough Conference, Sept. 1960; also International Conference on Scientific Information, Washington, DC, Nov., 1958. Vol. 1, p. 287-300.

[2] R. S. Hutton and others. *Jnl. Documentation*, Vol. 17 (March, 1961)., pp. 1-39.

[3] R. S. Hutton. "Review of Information Services," Roy. Soc. Empire Scientific Conference, 1946, Vol. 1, pp. 686-598.

[4] "Some Counterparts in Perspective," Nat. Federation of Science Abstracting and Indexing Services. Report on Visits to USSR, etc. Washington DC, 1960.

[5] *Proc. Intern. Conference on Scientific Information*, Washington DC, 1958. 2 volumes.

[6] R. S. Hutton. "The Communication of Specialist Information to Business Executives." Aslib 25th Conference Report, 1946, pp. 57-65.

[7] Cf. *Metallurgical Abstracts* of the Institute of Metals.

Human Element

Industry Should be Seen but not Heard

THE steel companies may just now be wondering if they live in a striving industrial economy or in one where industry is tolerated only so long as it upsets neither people nor their surroundings.

Sharp threats are uttered by the miners' representatives at the prospect of the Steel Company of Wales wishing to keep its materials costs down by importing special coal grades from the United States. The Coal Board argument about the lower price being temporary and dependent on low shipping rates is accurate on the facts, but for how long has it been wrong for a company, or an individual, to take advantage of a situation in his favour, however temporary? Any suggestion that even so the hostility of the miners would be aroused rests, openly or not, on the assumption that the miners are hostile to the idea of the steel industry applying other criteria than employment for their own industry.

Far away from the pithead wheels and the towering blast furnaces, in the quiet North Oxfordshire countryside another steel company, Richard Thomas and Baldwins, have suffered a reverse in the decision of the Minister of Housing, Mr. Henry Brooke, to reject the application to mine ironstone by opencast methods from just under 5,000 acres of land between Chipping Norton and Banbury.

Loss of Amenity

Special attention was given by Mr. Brooke to injury that would have occurred to amenities in the area. The Ministry Inspector conducting the public inquiry had concluded that opencast ironstone mining in the area would have caused serious damage and loss to agriculture and severe injury to rural, amenities by destroying natural features and by creating noise and disturbance.

Agreeing with these opinions, Mr. Brooke has stated that a relatively small part of the land would be taken out of use for the full period of the workings, although interference with agriculture would mostly be temporary and would be largely overcome by progressive restoration of worked out land. The effect on agriculture of the suggested developments was not in itself seen by Mr. Brooke as of sufficient reason for withholding permission.

The Minister's opinion that ironstone working should not be allowed in the area, "especially in the very attractive country south of the River Swere," without clear evidence of overriding economic need, was reached taking the agricultural considerations with the injury to amenities.

All the local authorities and other local and national organizations had opposed the applications, which would have meant, given approval, a rising rate of ore extraction from the site, reaching a million tons this year and increasing to the top rate of 4 million tons a year by 1965.

Putting on record his conviction that there was no over-riding economic need for the proposed mining, Mr. Brooke added his conclusion that too little weight had been attached by the applicants to the possibility of supplies from the Wroxton area. Ironstone working is already established at Wroxton, which is in North Oxfordshire, north of Banbury.

RoSPA Safety Award Won by John Laing

The outstanding industrial safety award, the Royal Society for the Prevention of Accidents' Sir George Earle trophy, has been awarded to John Laing Construction Limited.

The citation, by the National Industrial Safety Committee of RoSPA, reads: "in recognition of this company's practical and highly successful approach to the problem of accident prevention, in the difficult conditions inherent in building and civil engineering work, through the full acceptance of its responsibilities by management at all levels; and, in addition, in acknowledgment of the exceptional extent of the help readily given at all times by the company to further the safety of the construction industry as a whole."

By restricting the award for last year to the construction industry, RoSPA sought to draw attention in the industry to accident prevention. Described by one of its own executives as an industry identified in the public mind as a "killer" industry, the building trade has suffered a rising number of accidents. There were 61 more deaths last year than in 1959 and 2,250 more accidents that did not cause deaths. The year's provisional figures were 278 dead and 20,318 injured.

The Sir George Earle trophy is given each year to the company or industrial organization judged to have made the most significant contribution in the field of accident prevention. The achievements of John Laing Construction are rated comparable to those of any of the earlier winners of the trophy.

Sir Howard Roberts, president of RoSPA, presented the trophy at the National Industrial Safety Conference, at Scarborough, to Mr. W. Kirby Laing, the chairman of the company.

An English Student at the Chrysler Institute

The first British engineer to be selected for the Chrysler Institute of Engineering Graduate School, Detroit, is now engaged on his first year of his two year course.

He is Richard Alan Jones, who graduated from Cambridge last year in mechanical engineering. His two year course in Detroit leads to a Master's degree in automative engineering.

Before being flown to the United States, Richard Jones, who was selected from a number of university and technical college candidates, spent a week at the Chrysler Motors factory at Kew, West London, becoming acquainted with the company's vehicles.

Next year he will return to Britain as an engineer at the Chrysler works. For the moment, two of the aspects of American college life that have impressed themselves on Chrysler's new student are that where Cambridge students mostly ride bicycles, their American counterparts drive cars; and while British examinations are usually from memory, the use of textbooks is often permitted in technical and statistical examinations at the Chrysler Institute.

Traffic Engineers at Full Speed Ahead

Birmingham University has established the degree of M.Sc. (Highway and Traffic Engineering), the first qualification of its kind in the country. It is awarded to engineers who, possessing a first degree, successfully complete the one year course given at the new graduate school of highway and traffic engineering formed within the department of civil engineering at the university. For those who complete the course but do not have the requisite qualifications to register for a higher degree, there is the school's diploma in traffic studies.

The school held an open day recently so that representatives from industry and government departments could see the work being done. Sir Robert Aitken, the vice-Chancellor, welcoming the visitors, commented that it was very proper for a university to undertake the study of a current social problem that was both complex and highly technical.

Describing the work of his school, Professor Kolbuszewski said that it was not intended to produce "detached traffic engineers" trained only in the single specialist field. For the United Kingdom it seemed better to take the civil engineer with a wide training and some experience and to provide him with further training. Students spent twelve months on the course, the first nine within the school on lectures and project studies and the remaining three months on an approved site examining a major traffic situation.

Thirty Students

To complete the course students sat a written examination, submitted a report on their field studies and, if necessary, faced an oral examination. Lectures and laboratory work covered both road construction, including soil mechanics and the materials used, and the traffic problem. Under the latter heading came studies of the road user, traffic control, road furniture, alignment and layout of roads, parking, causes of accidents and their prevention, vehicle design, economics of transport and traffic planning. To supplement the work of the staff of the school, three outside lecturers are in regular attendance.

The cost of the first seven years of the school Professor Kolbuszewski put at £134,000, made up principally of £33,000 for the building—an attractive building in the modern style—£20,000 for equipment and £54,000 for staff salaries. In the present course there were nearly 30 students, from consulting engineers, contractors, local authorities in this country and from government departments overseas.

Among the visitors was Sir Richard Nugent, M.P., who as a junior minister at the Ministry of Transport had seen the need for such a school and had sponsored the appeal for the funds necessary for its establishment. He congratulated Professor Kolbuszewski on the speed with which the school had got started and added that it augured well for the speed of traffic in the future. Traffic congestion was a canker in the life of our affluent society and it was the traffic engineer alone who could properly provide the cure.

It was a sad fact Sir Richard noted when he reported that there were still 69 out of the 83 county boroughs, and 42 out of the 62 county councils, who employed no traffic engineers. Ending on a happier note, Sir Richard thought it was only a question of time before public opinion demanded that every local authority should be properly staffed with its complement of traffic engineers. There would then be a demand for more trained men than the school could possibly turn out, but the unique distinction remained to Birmingham University of being the pioneer in the United Kingdom in this vital field.

Dinner for Apprentices Past and Present

Sir Ben Lockspeiser, director and scientific adviser to the Tube Investments Group, Sir David Eccles, the Minister of Education, and Mr. William Carron, president of the Amalgamated Engineering Union, will be among the speakers at the National Apprentices dinner, being held in London on 30 May in celebration of Commonwealth Technical Training Week.

The Duke of Edinburgh has agreed to be Patron of the dinner, which is being organized by the Industrial Welfare Society. The dinner, at the Café Royal, is being attended not only by past apprentices who have risen to positions of power and influence in industry, but also by apprentices in the course of training. It is understood that the invitation also embraces the small but important number of girl apprentices.

Tickets for the dinner (2 guineas) are available from the Industrial Welfare Society, 48 Bryanston Square, London W1.

United States Research Report

The research information subcommittee of the American Institute of Industrial Engineers has repeated its annual request for reports on research carried out in what the Institute terms Industrial Engineering.

The sources from which the subcommittee gathers in its information include universities, industrial organizations, research institutions, and non-profit making organizations such as Government agencies and the professional societies. The research abstracts are published, providing a useful addition to the flow of information through the universities, the technical colleges and industry.

The areas of work specified by the AIIE are:

Work Measurement
Methods
Facility Planning
Applied Psychology
Engineering Economics
Organization Planning
Materials Processing
Production Planning and Control
Data Processing Systems Design
Applied Mathematics
Costs and Cost Control
Industrial Engineering Education.

The address to which the Institute asks research information to be sent is: Dr. Jay Goldman, chairman, Research Information Subcommittee AIIE, Department of Industrial Engineering, Washington University, Saint Louis 30, Missouri, USA.

The Building of Guildford Cathedral

Construction of a cathedral demands work that will remain in a serviceable condition for many hundreds of years. The author has been responsible for the design and supervision of the structural engineering for the newly consecrated Guildford Cathedral.

By Burnard Geen, M.I.C.E.

GUILDFORD and Liverpool are the only two Cathedrals to be built in the United Kingdom on entirely new sites in the last 500 years.

Six acres of land on the top of Stag Hill, near Guildford, were given to the Cathedral Committee by the Earl of Onslow, and to prevent encroachment of future building a large area of land around the site was given by Viscount Bennet, the Prime Minister of Canada, an act of great generosity and vision.

On 17 May, 1961, the Cathedral was consecrated in the presence of Her Majesty the Queen and the Duke of Edinburgh; a moment when the architect, Sir Edward Maufe, R.A., could look back with justifiable pride upon his masterpiece, one of the great buildings of the century, beautiful, serene, and entirely suited to the purpose for which it was designed.

Stag Hill, with its crest 80 ft above the Guildford-Godalming By-Pass, a slow fall to the west and a steep fall to the east and south, is nevertheless practically level within the 365 ft length and 150 ft width of the Cathedral. It provides fine unimpeded views in all directions and possesses the advantage that the long axis of the Cathedral is nearly true east and west.

The building as it stands today is not quite complete since the Lady Chapel and Canada Chapel at the east end, and the north and south garths at the west end still remain to be built, while the sacristy and the upper portion of the tower are now in hand. Another length of road at the south, to connect Alreyford Road with the forecourt, has been left for the future, when funds are available.

Started in 1936, what is seen today is the result of 16 years effort, nine years having been lost from 1939 to 1948.

The general appearance of the building, free from buttresses both inside and out, creates an impression of loftiness. This has been made possible by the construction adopted, the curved arch forms throughout being designed as freely supported beams to eliminate arch thrust.

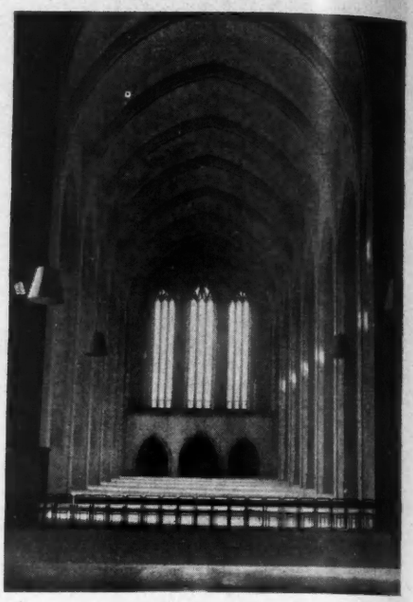
Though the problems involved are not of exceptional difficulty or novelty, they are in a sense of a different character from most strictly utilitarian work.

A characteristic of a structure of this kind is that for all practical purposes the whole of the loads apart from wind and snow are dead load, capable of fairly precise estimation.

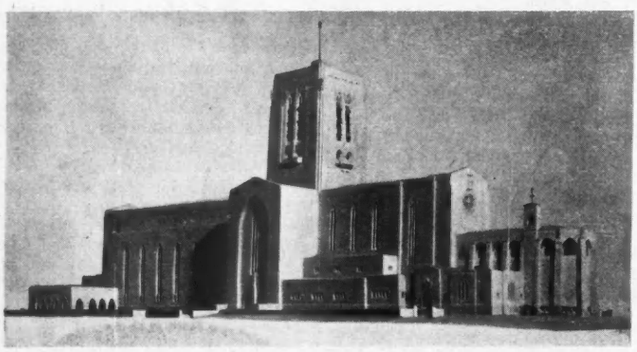
With many intricate shapes in the vaults and roof, including double curvature forms, curved beams, spiral staircases and the like, the drawing office work was especially demanding. The aim has been to deal with such items so that nothing was left to be settled on the site, the practical difficulties all being overcome on the drawing board, where a great deal of work was required for a small amount of constructional work executed.

It is not an everyday problem to build in such a way that, excluding violence, the work is certain to remain in good serviceable condition for hundreds of years, and a brief note of the general standards of work adopted follows.

Boreholes indicated brown clay above a fairly level bed of hard blue clay, beginning at about 25 ft below nave floor level and of great depth. Samples from various depths showed the presence of sulphates, but without serious concentration; and the absence of any possible flow of water led to the opinion that Portland cement would remain unaffected.

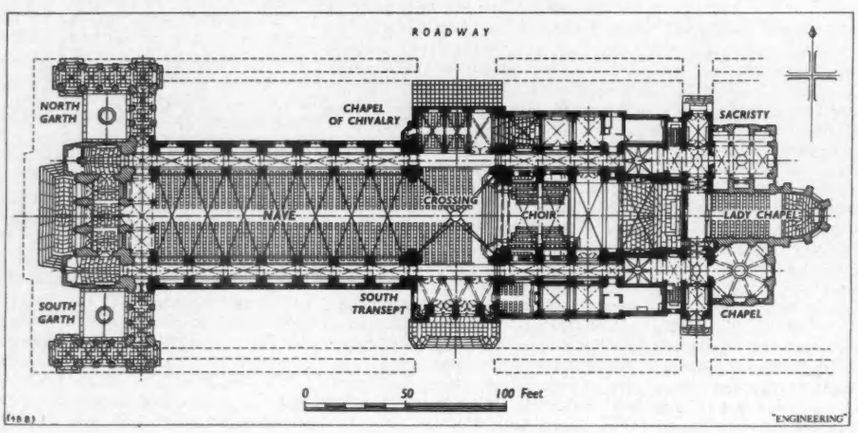


The Engineers' Arches—subscribed by the profession. Another £600 is still required.



The south-east aspect of the Cathedral.

Plan of the work. The north and south garths and the Lady Chapel are still to be built.



The original designs for the foundations proved satisfactory. They called for 778 precast piles 15 in square driven by a 4 ton hammer falling freely through 36 in to a set of 12 blows to the inch; the length of 50 ft finally adopted had been determined by driving six test piles, and all the piles have been driven a minimum of 20 ft into the blue clay. Test loads up to 75 tons gave a settlement of $\frac{1}{16}$ in at 28 days. Loading is limited by the design to 50 tons per pile, except in 36 pile groups under the four main piers, where it was reduced to 45 tons per pile.

In all the deep portions of the foundations, including the crypts and tunnels, where it was certain that in time water would tend to accumulate, a generous system of drainage has been provided, consisting of nests of varying numbers of 4 in agricultural pipes laid to a fall of 1 in 100 and covered above and at the sides with 24 in of screened coarse shingle.

The road, about a third of a mile long, mounts the hill by following its slope as closely as possible, thus avoiding all unnecessary disturbance of the clay soil, and permitting a most dramatic view of the cathedral to be obtained. Starting about 75 ft below forecourt level, it runs level for some distance then for about 300 ft rises at a slope of 1 in 10·2 flattening out to 1 in 40 up to the forecourt. To an observer coming up the road, the main body of the cathedral is obscured until nearing the end of the steep slope, when it appears to rise rapidly, until its full height is disclosed.

The 24 ft wide road was built upon a 3 in layer of rolled clinker and a 2 in layer of concrete. The wearing surface comprises a reinforced concrete slab 8 in thick at the centre, with cross-fall to each side of 1 in 40 and expansion joints set at 80° to the axis of the road. The joints are provided with copper expansion strips and steel dowels free to move at one end. Extensive drainage at each side of the road ensures that the water content of the clay shall, as far as possible, remain constant. After 25 years of life the road remains in perfect condition.

As excavation for the foundations was in clay and the period of construction wet, because of the presence of the sulphates, a 1 to 6 concrete casing was laid around and below all ground

beams and pile caps, and the inner surfaces painted with bitumen before casting the structural members. This removed as nearly as possible all sources of contamination which might otherwise affect the work in the future; it also permitted a very thorough ramming to obtain dense concrete to prevent corrosion of the steel, a much more important matter than mere structural strength.

Rapid hardening Portland cement was used for the piles, and ordinary slow setting Portland for the remainder of the work.

Careful and repeated grading tests of shingles and sand were carried out, and to control bulking of the sand it was first tipped into a pit and inundated. Although this gave good results, it was discontinued in the superstructure work and other means adopted. Proportions of 27 cu. ft of ¾ to ¼ in shingle and 11¼ cu. ft of sand to six bags (672 lb) of cement for the general work, with the cement content increased to seven bags in the piles, gave very consistent results of around 5,000 lb per sq. in at 28 days, and 4,500 lb per sq. in at seven days in the case of the piles.

Pressure on the brickwork in the four tower piers and other heavily loaded members is estimated at 26 tons per sq. ft. The Lingfield Engineering wire-cut bricks used gave average test results of 379 tons per sq. ft, and a sample pier 8¾ in by 8¾ in by 27½ in high held up to 181 tons per sq. ft before cracks first appeared, with the final failure occurring at 275 tons per sq. ft, from which it appeared that an ample margin of strength remained. The strength of the mortar at 28 days was found to average 5,035 lb per sq. in.

Apart from these special bricks, all the remainder used in the cathedral are made at the adjoining brickworks from clay from the hill itself. The bricks are hard burnt, of varying texture, and rose coloured, 2¼ in thick.

The general roof construction is high pitched, of reinforced concrete slab covered with copper, and supported on curved beams. Curved vaults spring from the bottom of the beams providing crawling ways in between for access to lighting and suspenders for scaffolds that may be required for cleaning or attention to the acoustic plaster. To provide facility for maintenance, repairs or replacement of plant, underground tunnels and crawling ways are provided along the centre line of the building, with three cross branches and expansion joints at intervals; any accumulation of water outside is prevented by the generous land drains around all underground work.

In the roofs over the north and south transepts, the beams are exposed, and their slender two-centre pointed twin-arch form is particularly striking where they rise to the full height of the roof.

At the crossing, four curved main beams carry the full load from the main vault, tower walls above, ringing chamber floor, tower roof, and portions of chancel and nave as well as the north and south transept roofs. By making the jointed arch stones in channel form, the stones acted as permanent shuttering for the heavily reinforced beams and a true form was easily given to the soffits of the arches. The beams were brought up in equal stages on all four sides at the same time, but the construction of the pendentives proved especially troublesome. The vaults over the crossing are integral with the beams and also with the bell floor over, which at present acts as a temporary roof.

The many varieties of shape that have been built for the vaulted roofs of aisles, transepts, porches, ambulatory and elsewhere show how very suitable reinforced concrete is for such requirements.

Below ground, where the work is generally massive, all the surfaces which are to be seen are bush hammered, producing an excellent texture, and no attempt has been made to obscure lines where lifts in concrete occurred, these joints being left to tell their own tale.

Consulting Engineer: Burnard Geen, M.I.C.E., 122 Victoria Street, London SW1.

Contractors: Foundations—Trollope and Colls, Limited, 41-44 Great Queen Street, London WC2; and Superstructure—Dove Brothers Limited, Clondesley Place, London N1.

The Most Developed Shopping Centre in Europe

Work has begun on the Bull Ring shopping and recreational centre in Birmingham. The scheme covers four acres right in the middle of Birmingham and will provide a complete shopping centre with maximum access by public and private transport; there will also be restaurants and banqueting facilities. The centre will have car park accommodation for more than 500 cars and will include an office block. The whole area will be contained "below one roof" and will be fully air conditioned. It is thought 40,000 people may be in the centre at any one time.

The scheme is being promoted by the Laing Development Company and construction will be by John Laing Construction Limited. It forms a major part of the City of Birmingham Inner Road Scheme, a comprehensive plan for the development for the whole of the centre of the city, involving, in particular, a major road project designed to meet the needs of 20th century motoring today and as far as future developments can be forecast. A considerable measure of segregation of vehicles and pedestrians has been adopted, and extensive car parking facilities have been made below those sections of the ring road that are elevated.

Claimed to be the most highly developed shopping sites in Europe—if not in the world—the scheme provides for 350,000 sq. ft of retail shopping space divided among about 140 shops, departmental stores and supermarkets, and two market areas, one of 36,000 sq. ft for general trading and another of 14,000 sq. ft for a fish market.

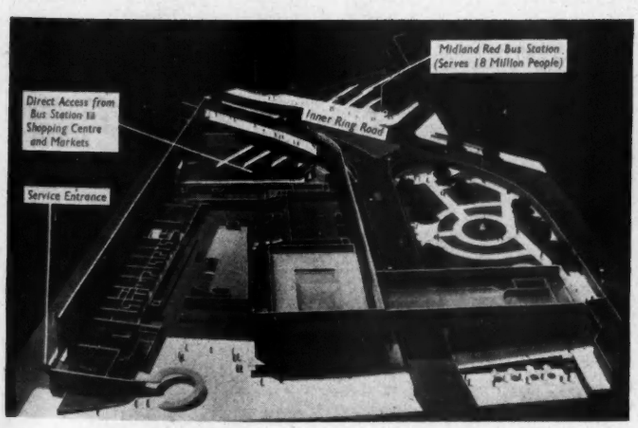
Ample arrangements are available for bringing people to the centre. Within the precincts of the scheme there will be the new underground bus station for the services which serve the region around Birmingham; and for more local shoppers many of the city's internal bus services pass along the roads that form the perimeter of the site. For rail travellers there will be a covered pedestrian link with nearby New Street station. The floors for the multi-storey car park will be fed by high speed lifts and, in general, drivers will take their own cars to and from the parking points. Loading bays are to be built for 50 lorries. Altogether there will be 15 entrances at different levels. Internally there will be 29 escalators capable of moving 128,000 people an hour.

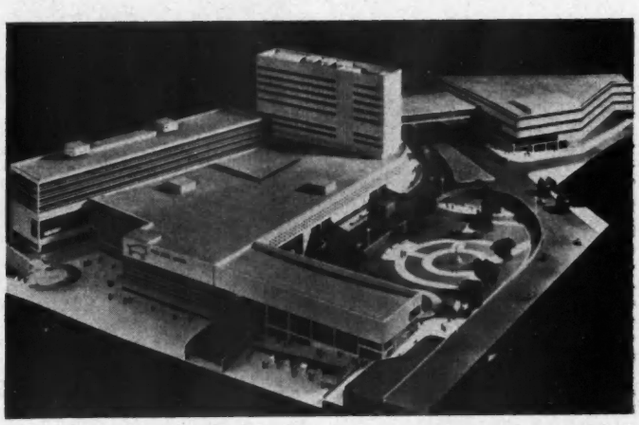
The whole area is to be air conditioned. Air will be cleaned and then heated or cooled, as the case may be, before distribution to many points throughout the centre. Every shop will have a separate control over the incoming air but the intention is to keep the temperature up to 65° F throughout the winter and to reduce the temperature to not more than 5° F below the outdoor temperature in warmer times. This both limits the size of refrigeration plant required and avoids the discomfort that is experienced when going quickly from a hot atmosphere into an overcooled building.

Construction is to be in traditional reinforced concrete for the framing, with precast slabs for the walls. Precast members for the framing have been avoided primarily because experience on other development sites has shown the need to keep maximum flexibility for as long as possible. Precasting necessarily demands an earlier settlement of purpose than *in situ* concrete members which can be varied almost up to the time of fixing the shuttering.

Shop loading requirements are generally heavy and a live load of 85 lb per sq. ft has been assumed. Because of the savings possible in the columns and foundations by keeping the dead loading of floors to a minimum, extensive studies of floor types were made by the architects, both in terms of material and labour costs as well as from the point of view of weight and load carrying capacity. A trough type floor finally proved most acceptable.

The site is substantially clear though a few small buildings remain to be demolished. It is expected to have the engineering work completed by May 1963. Fitting out will then proceed simultaneously in all the shops and the centre opened in the autumn of 1963.

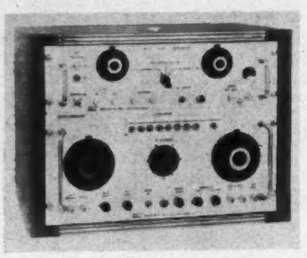

Midland Red Bus Station (Serves 18 Million People)
Direct Access from Bus Station to Shopping Centre and Markets
Inner Ring Road
Service Entrance



The Bull Ring, Birmingham: four acres under one roof. It will be fully air conditioned. In situ reinforced concrete construction will be used.

COMPONENT TESTER

Standing Wave and Attenuation



THE voltage standing wave ratio and the attenuation values of radio frequency components and circuits can be determined by a new Telonic instrument.

The test set uses a pair of coaxial switches operating at 30 cycles per second to produce a dual oscilloscope trace. The two traces, representing a reference value and an unknown, provide instantaneous readings of voltage standing wave ratio (VSWR) or attenuation for the device under test.

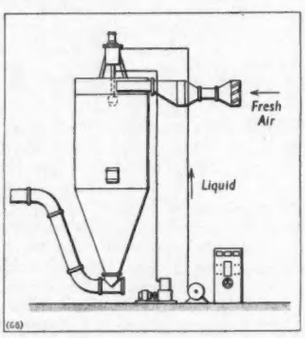
In operation the unknown device is connected to the proper terminals on the test set producing a trace of undetermined value on the scope. The VSWR or attenuation dial is then rotated to obtain a response on the scope that matches the trace, and the value is read from the dial face.

The model SP160 operates over a frequency range of 200 to 475 megacycles and uses a Telonic sweep generator to provide the swept signal. A comparator module equipped with input terminals and two RF attenuators is incorporated.

The generator section operates at a fundamental frequency using a sweep oscillator with a precision vibrating capacitor and a silver plated beryllium copper diaphragm for reliability. The generator response is flat within 5 per cent over its maximum sweep width and the output is over 0·75V into 50 ohms; it is equipped with a variable frequency marker. For various applications the set can be supplied with sweep generators covering frequencies up to 1,000 megacycles and attenuators can be provided for any values desired. *Sylvan Ginsbury Limited, 8 West 40th Street, New York, NY, USA.*

SPRAY DRYER

Controlled Particle Size



DRY powder of predetermined particle size is produced from the IWK spray drying machines.

The liquid to be dried is atomised into a tower by a nozzle arrangement of which there are several types. Hot unsaturated air is led in simultaneously and evaporates the moisture into small droplets. The remaining dry residue settles as a fine powder and is extracted either direct from the conical section of the tower or from a first stage separating cyclone. In either case it is quickly removed from contact with the saturated air. Further extraction can be carried out if desired by secondary cyclones, wet washers or hose filters, and these smaller particles returned to the liquid for re-circulation.

Since the air and liquid flow in the same direction, the hottest air is in contact with the wettest powder, and the drier powder is not damaged by overheating. The process is suitable for delicate substances which can be handled without damage or deterioration. Steam, gas, oil or electricity can be used for the air heating according to the availability.

Complete plants are available in single tower construction to handle water evaporation quantities from 10 lb per hour (an experimental unit) up to 4,500 lb per hour. Doors are provided at all levels for access to the tower and there is an inspection window for the atomising zone. The construction material used can be chosen to suit the application. *Engineering Appliances Limited, 3 Buckingham Place, London SW1.*

ANNUNCIATOR

Visible and Audible Warnings

BOTH visible and audible warnings can be given by the annunciator units SIG/O and SIG/C.

These units are designed to operate in conjunction with pressure and level switches and the like, where a pair of contacts is operated when a dangerous condition is reached. The first model is for initiating contacts that are closed for alarm and the second for those which open.

The units are self contained and incorporate a red and a green warning lamp and output contacts for operating an audible alarm. In the normal condition the green lamp is illuminated; when the initiating contacts operate the red lamp lights and the output contacts close. On pressing the cancel button the audible alarm ceases but the red lamp remains alight until the initiating contacts are restored to normal. An additional feature is the test switch for checking the unit.

The normal operating supply is from 200/250V ac and the switching capacity of the audible warning contacts is up to 3A at 250V ac. The units are built into robust sheet steel casings and in the standard form as illustrated are suitable for wall mounting. Dimensions are 6 in by $4\frac{3}{16}$ in by $5\frac{5}{16}$ in over the lamps. *Londex Limited, Anerley Works, 207 Anerley Road, London SE20.*

TRACTOR SHOVEL

For Heavy Duty Handling

LATEST in the tractor shovel range is the Trojan model 204 which has a capacity of 2 cu. yd.

This is a four wheel drive machine powered by a Leyland UE350 engine which has a rated output of 105 hp at 2,200 rpm. Bore and stroke are 3·96 in by 4·75 in and the torque developed is 270 lb-ft. The transmission is through a three speed forward and reverse box and a 3·5 to 1 torque convertor mounted integrally in the housing. The clutches are hydraulically operated. Front wheel drive is normal and there is a four wheel drive selector.

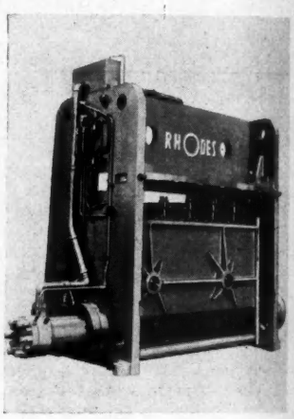
The steering is power assisted by a hydraulic booster giving a turning radius of the outside rear drive tyre of 22 ft. There are four-wheel hydraulic brakes for running with vacuum booster, and a mechanical hand brake on the propeller shaft for parking.

The bucket has a rated lift of 12,000 lb with a clearance in the tipped position of 8 ft 10 in. Forward clearance when tipped is 2 ft 8 in from the front wheels. Time to raise to the full height of 14 ft 3 in is 8 sec and to lower is 7 sec. The double acting hoist cylinders are $5\frac{1}{4}$ in diameter by 30 in and the bucket cylinders are 5 in diameter by $15\frac{3}{8}$ in; both are chromium plated. Trojan reverse curve safety arms are used.

Other features of the machine are low load carrying position; the straight line horizontal thrust; and the independent bucket action. The bucket is 94 in wide spanning the wheels; three capacities are available for 2 cu. yd (standard), $2\frac{3}{4}$ cu. yd and $1\frac{3}{4}$ cu. yd, for light and heavy materials respectively. *Yale and Towne Manufacturing Company Limited, Willenhall, Staffordshire.*

UP-CUTTING SHEARS

Electro-Hydraulic Operation



THE UP-CUTTING shears in the illustration were produced specially for use in a stainless steel production line.

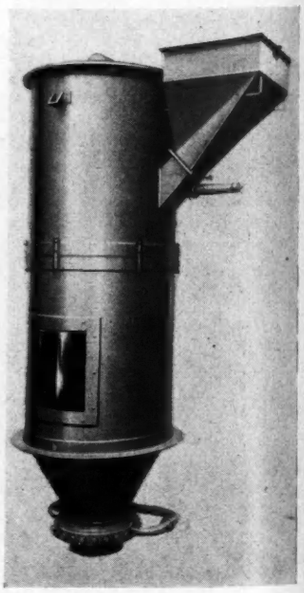
The shears are at the end of the line and cut the sheet to length. They are capable of cutting a maximum thickness of 1 in in mild steel or of $\frac{3}{4}$ in in stainless steel with a maximum width of 6 ft 6 in. The cutting rate of the shears on plate up to $\frac{1}{4}$ in thick is up to 20 strokes per minute and on thicker plate up to 6 strokes per minute.

The patented "Fluid Drive" method of actuation has an electro-hydraulic source of power which is used to actuate the mechanical motion of the shears. The hydraulic power provides an easily regulated and controlled motive force while the mechanical action ensures high speeds with precision of movement. There are no clutches, rotating shafts, gears or flywheels. The fluid drive limits the load that can be put on the machine and eliminates accidental overload damage. The relief valve in the circuit returns the beam to the top of the stroke if an overload should develop.

Being of the up-cutting type the shears allow the line to be maintained at a fixed height and the necessity to fit an automatic dipping conveyor in the outgoing side of the line is avoided. *Joseph Rhodes and Sons Limited, Wakefield, Yorkshire.*

POWDER MIXER

Uses Compressed Air



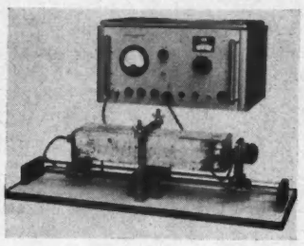
VERY quick mixing of powders is claimed for the Airmix machine illustrated.

Air is used as the mixing agent, there being a series of nozzles in the base of the machine arranged to impart a spiral motion to the particles. A preset electric control unit governs the mixing time and the intervals between the successive blasts of air. Atmospheric pressure is maintained within the machine itself.

Textile filters that can easily be renewed are fitted and the body can be cleaned by a single blast of air in a matter of seconds. A pneumatically operated valve at the base of the cone controls the discharge of the mixed powder and any tendancy to bridge or stick can be overcome by a short blast of air. Standard sizes range from 2 cu. ft capacity up to 800 cu. ft; but a small quantity can be mixed efficiently in any size body. The Airmix can be modified to include liquids in the mixing. *Wm. Gardener and Sons (Gloucester) Limited, Bristol Road, Gloucester.*

MATERIALS TESTER

Uses Resonant Frequency



THE elastic constants of a regularly shaped specimen can be determined non-destructively by the materials tester model SCT4.

This unit works on the principle that if a specimen be vibrated longitudinally its dynamic modulus may be found, and if vibrated torsionally the modulus of rigidity can be derived. By measuring the width of the resonance curve at the point where the amplitude of oscillation has fallen to $\frac{1}{\sqrt{2}}$ of its maximum, the damping of the specimen may be obtained.

The SCT4 consists of an accurately calibrated oscillator which may be coupled to a vibrator for excitation of the specimen, and of an amplifier feeding a meter which measures the signal from a crystal pick up in contact with the vibrating specimen.

Tests can be carried out on a wide range of materials from concrete to metals and the technique is particularly useful for studying the property changes which result from heat treatment, irradiation, acid attack, or frost damage.

A standard test bench is available which will take a square prism of up to 6 in by 6 in by 28 in. A moving coil vibrator and piezo-electric crystal are supplied with the equipment. The unit itself measures 21¾ in by 14 in by 11¾ in and weighs 64 lb. The oscillator frequency range is from 100 c/s to 10 kc/s with an accuracy of calibration to ± 0·1 per cent. The output is 3W and the consumption 100W approximately from either 100-115V or 200-250V 50 cycle mains. *Cawkell Research and Electronics Limited, Scotts Road, Southall, Middlesex.*

VARIABLE SPEED GEAR

Hydraulic Operation

THE latest addition to the range of variable speed gears is the model AM26 illustrated.

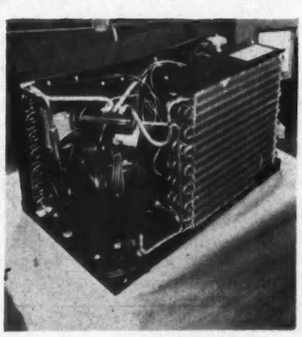
This unit has a transmission capacity of 10 hp for an input speed of 1,400 rpm. This would fall to 5 hp for a speed of 700 rpm. The variation in output speed is over a 27 to 1 ratio with stepless variation. The model illustrated is fitted with handwheel control but remote electrical and drilled lever controls can also be fitted. Speed adjustments can be made with the drive running or stationary and loads can be picked up from zero rpm. The equivalent output torque is 450 lb-in.

Assuming a constant input speed, the average no load/full load pull down speed is 25 rpm with an acceptance limit of 40 rpm. On starting from cold, about one-half this pull down will occur as drift during the first 30 to 35 minutes of running. The movement of the control gives linear variation of the output speed, modified slightly by the pull down of both motor and gear. At 70° F ambient temperature the settled oil sump temperature will be approximately 120° F.

Dimensions of the gear unit alone including the shafts are 28¾ in long by 18¾ in wide by 18¼ in high. The units can be supplied for direct coupling to a motor or with a motor mounted above and driving through V belts. There is a range of flange mounted reduction gears that can also be fitted to the units. *Carter Gears Limited, Thornbury Road, Bradford, Yorkshire.*

ROOM CONDITIONER

Reverse Cycle Operation



BOTH heating and cooling can be supplied by an Airtemp room conditioning unit now available.

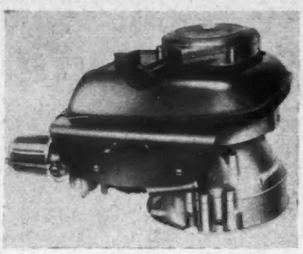
The unit is rated at 1 hp and is designed to operate on the reverse cycle principle, becoming in effect a heat pump instead of a refrigerator. Exchange is air-to-air with an inner and outer exchanger linked by circulating fluid. The compressor unit is hermetically sealed.

The coefficient of performance of these units ranges between 6 and 7. Control is by a thermostat or when being used as a cooler only by a humidity monitor. Dehumidification is effected by draining moisture off the air-to-fluid exchanger, allowing it to run along the base tray of the unit to the outer fan on which is a slinging ring that picks up the water and disperses it in the outer air flow. The steel tray is protected against corrosion by zinc coating and by paint. At 50 per cent relative humidity the moisture removal rates range from 1½ to 3¼ pints per hour.

The refrigerant is Freon 12 and the direction of flow is controlled by a solenoid valve also hermetically sealed, with the leads passing through Fusite glass seals. The refrigerant passes from condenser to evaporator through a long capillary that imposes a pressure drop, and from the air cooler arrives again at the valve where it is returned to the pump suction. A duct between the two fan circuits can be opened to introduce fresh air into the room. *Chrysler Airtemp Limited, Bowater House, Knightsbridge, London SW1.*

VERTICAL SHAFT ENGINE

Four Stroke



A NEW lightweight engine with a vertical shaft is now on the market.

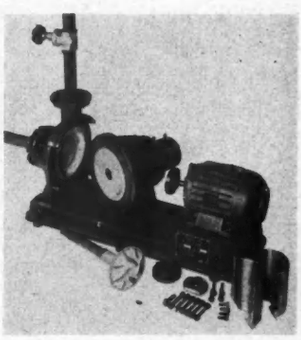
The unit is designed especially for use on rotary grass cutters and similar implements and operates on the four stroke cycle. The single cylinder has a capacity of 150 cc with a bore and stroke of 63 mm and 47 mm respectively and is thus following the "oversquare" trend. It develops its peak rating of 3·23 bhp at a shaft speed of 3,600 rpm. Being built extensively of light alloys it weighs only 26 lb complete with tank, recoil starter, silencer, and air cleaner.

The cylinder block, cylinder head, crankcase, oil sump and flywheel are all light alloy pressure die castings designed for strength and rigidity with lightness. The cylinder and crankcase are cast integrally, the cylinder head being detachable. The cylinder has a cast-in iron liner with nickel alloy valve seat inserts and separate valve guides. Exhaust and inlet valves are made of silchrome steel and are interchangeable. Tappets are cast iron. The crankshaft is a one piece casting with an alloy connecting rod and aluminium alloy piston. Steelbacked bronze faced bearings are used.

Ignition is by flywheel magneto and the contact breaker assembly is totally enclosed with a rotating panel through which adjustments can be made to the points without removing the flywheel. The carburettor has idle and speed adjustments. Control is by airvane governor. The upper crankshaft bearing is pressure lubricated by a pump and the lower bearing runs submerged. Overall dimensions are 15¾ in by 11¼ in by 11½ in excluding shaft extension. *Villiers Engineering Company Limited, Marston Road, Wolverhampton.*

CENTRIFUGAL PUMP

Ceramic Lined



A CERAMIC lining makes the Transkem type TK pumps suitable for handling almost all liquids except hydrofluoric acid.

The lining is made of Petrox C which is abrasion resisting allowing suspended sand or carborundum slurry to be pumped. It also has a high mechanical strength and resistance to thermal shock; it will handle liquor temperatures of 100° C and above.

The pumps are made in two basic sizes of 1½ in and 2 in, most parts of each being interchangeable. For each size there is a choice of three impellers and two speeds. Thus an effective range of 12 pumps is available covering capacities from 5 to 130 gallons per minute at heads from 14 to 122 ft.

The impellers are of open design and are provided with special back vanes to give a partial vacuum in the gland on normal installations in order to overcome gland leakage. Where there is a high positive suction head a mechanical seal is recommended. The volute casing with the suction and outlet connections is mounted directly on the base plate so that the pipe work is not disturbed during inspections. To withdraw the moving parts the rear casing complete with impeller, shaft, and bearings, can be slid back a few inches and then swung round giving complete accessibility; the bearing arrangement is not disturbed if the impeller has to be replaced for any reason. *Transkem Pumps Limited, Sunlight House, Quay Street, Manchester 3.*

POST DRIVER

Simple Action

SIMPLICITY is one of the great features of the Drivall post driver.

The illustration shows a model fitted with extension handles; normally the side handles of the tool are held directly. The tool itself consists of a cylinder of iron closed at one end. It is fitted over the post and raised a foot or so and then banged down. The stroke being directly vertical, the full force goes into driving the post, which may be of any shape.

Since the head of the post is enclosed by the cylinder there is no splitting of the top as happens when a hammer or mallet is used. It is claimed that the post is firmer than if it had been fixed in an excavated hole with the earth rammed home. Posts may be wood or concrete and there are eight sizes of Drivall to cover maximum post diameters from ¾ in to 7¾ in. The small sizes have two handles for one man operation; the largest is intended for use with four men. A concrete breaker works on the same principle. *Drivall Limited, 207 Crescent Road, New Barnet, Herts.*

Servicing Aircraft Anywhere, Anytime

How one firm handles the problem of having its service engineers in the right place at the right time. With a highly technical product in constant use, this is a vital part of the firm's function.

THE activities of the Dowty Group, as might be expected of a leading aircraft components manufacturer, have always tended to be far flung. Their first order, in 1931, was from Japan. It brought into being Aircraft Components Limited, the precursor of Dowty Equipment Limited, to supply six internally sprung aircraft wheels to the Kasawaki Company. Today, the group supplies a diversity of rather more sophisticated products for aircraft built in this country, Europe, North and South America, and the Far East.

As will be shown on their stand at the Paris International Aeronautical Exhibition next week, Dowtys have supplied components for such currently successful aircraft as the Armstrong Whitworth Argosy, the Avro Vulcan, the Bristol Britannia, the Blackburn Buccaneer, the de Havilland Comet, the Fokker Friendship, the Folland Gnat, the Hawker Hunter, the Gloster Javelin, the English Electric PI Lightning, the Vickers Viscount and Vanguard, and the Handley Page Herald and Victor. Interesting current projects include components for the Japanese YS II and for the vertical-take-off P1127.

However, it is not sufficient to supply components for these aircraft. It is also vitally necessary to ensure that manufacturers and operators, wherever they make or deploy their aircraft, can rely on an efficient service organization to back up the product. After sales service is an important selling point in most markets—more so than many manufacturers are prepared to admit—but in the aircraft and aircraft components industries, where safety is a first consideration and loss of flying time can be a commercial and engineering catastrophe, a dependable service organization is essential. This is even more true when, as in this case, the components concerned—propellers, undercarriages (a typical main undercarriage is shown in Fig. 1), gearboxes, hydraulic systems and fuel systems—are of prime importance to the safety and effectiveness of an aircraft.

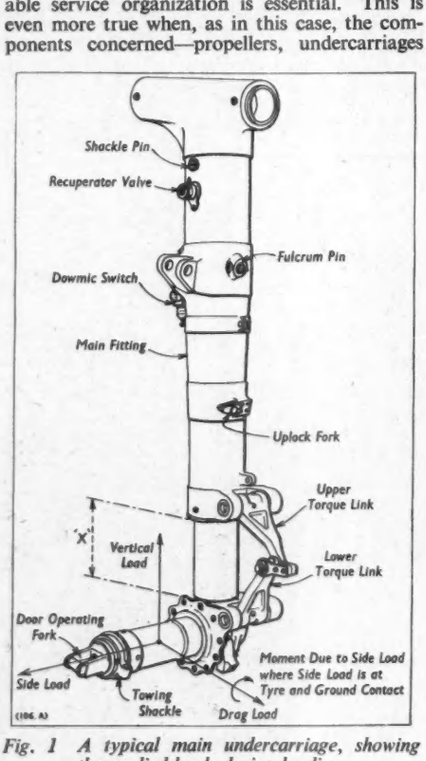


Fig. 1 A typical main undercarriage, showing the applied loads during landing.

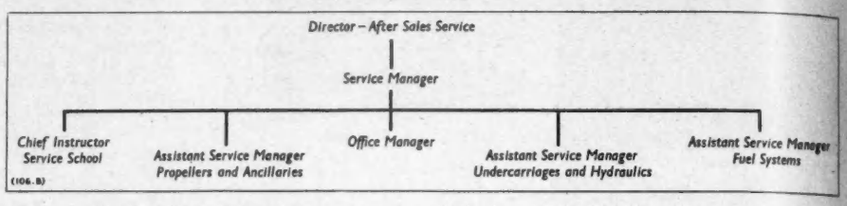

Director – After Sales Service
Service Manager
Chief Instructor Service School
Assistant Service Manager Propellers and Ancillaries
Office Manager
Assistant Service Manager Undercarriages and Hydraulics
Assistant Service Manager Fuel Systems
(106. B)

Fig. 2 The management structure on which the service department is based.

The Group has always appreciated the value of the service engineer function but a service department, as such, was not constituted until the war. Earlier, servicing was carried out on an *ad hoc* basis by production personnel. Mr. W. S. Spires, the present After Sales Service Director, used to be one of the production staff employed in this way from time to time.

During the war the level of production justified—in fact, necessitated—the creation of a separate service department, a department which, based on the management structure in Fig. 2, has now grown into a comprehensive world-wide organization equipped to handle any Dowty aircraft component anywhere. The addition to the group of Rotol Limited in 1959 has made the service department yet more comprehensive and flexible, albeit, by its very size, more problematical to administer and to manage.

PRIMARY PURPOSES

Broadly speaking, the service engineer has three primary objects in life, namely, (*a*) to ensure customer satisfaction, the customer being an aircraft manufacturer or a civil or military operator; (*b*) to expedite repairs, either by on the spot action or by quick liaison through his department and the firm's organization; and (*c*) to feed back information on the performance of equipment in the light of experience of particular operating conditions. Coordinating and fully utilizing engineers engaged on such tasks throughout the world is obviously a complicated exercise in management.

The department is virtually an amalgam responsible for the established products of Dowty Rotol and Dowty Fuel Systems. Some of the 45 service engineers are specialists in the products of one of these companies in particular—six of them have specialist knowledge of fuel systems, for example—but it is the group's policy that, while utilizing such knowlege to the full, each service engineer shall be familiar with the products of the other company.

Engineers are therefore brought back to the Cheltenham factories from time to time not only to acquaint them with the latest developments in their own field but also to train them in the servicing of the other products of the group, thus widening the scope and utilization of individual service engineers.

However, the field covered by the individual engineers does not end with aircraft components. Based on the knowledge of hydraulics gained in the development and manufacture of these components, the group has since the war been involved in the production of mining, railway and agricultural equipment. There is a separate service organization operated by Dowty Hydraulic Units to handle these non-aeronautical products but liaison between the two service departments is close, and where an aircraft service engineer happens to be based near non-aeronautical service work he can be switched to it in an emergency.

For example, a service engineer based at an aircraft factory near London recently advised on the installation of the hydraulically operated doors for a new building in Whitehall. The life of a service engineer is certainly varied.

Rather more than half the service engineers are usually based in this country at any one time, advising manufacturers, operators, the RAF and the Admiralty, but they are always at standby to make flying visits overseas when necessary.

Of the service engineers operating abroad, some, such as a man who has been in Australia for the past four years and another who is in India, are based more or less permanently in a particular country. The Australian-based engineer has been concerned chiefly with servicing components on something like 24 Fokker Friendships and over 30 Viscounts. The engineer in India has been engaged on landing gear, flying controls and hydraulic systems for the initial prototype of the new Indian fighter, the HF 24. He has also been doing consultancy work on the production of the Folland Gnat and the operation of various aircraft for India Air Lines—an example of the way in which service engineers are widely utilised wherever they are available.

Assignments take engineers to a variety of countries and climates, as might be gathered from Figs. 3 and 4, and demand that they should be not only good engineers but good diplomats.

Typical of the department is an engineer who has just returned from a six months' tour in Germany where he has been advising Roder Prazision of Engelsbach on the layout and methods for overhaul and repair units for the West German Air Force. He is now back at the parent company for a few weeks being briefed for an assignment in Turkey. There he will set up service installations for the propellers and undercarriages fitted to Viscounts and to Fokker and Fairchild built Friendships.

Another engineer is leaving shortly for Japan to get under way the servicing arrangements for the Dowty Rotol equipment in the new YS II. While he is out there he will also cover the Friendships and Viscounts operated by All Nippon Airways. Another engineer is scheduled to supervise the setting up of Viscount propeller overhaul equipment for Australian Air Lines. In fact, during the next few months service engineers will be undertaking special assignments in most European countries from Sweden to Italy (where Fiat are a customer), as well as further afield in places such as the Argentine.

The activities of all these engineers, wherever they operate, are controlled by the Service Director and the Service Manager, Mr. D. G. S. Barrett, from the group's Arle Court, Cheltenham, headquarters. There is, however, a special relationship with the service organization in North America.

NORTH AMERICA

Operating from Washington, the USA and Canadian service department is a combination of Dowty Canada and Rotol Incorporated and is ultimately responsible to the main group organization but, because of its size and the peculiarities of the North American market, has a high degree of autonomy in its day-to-day operations. The service engineers working in the North American offshoot organization bring the total number of Dowty service engineers up into the mid-fifties.

At present company engineers are servicing components on eleven types of aircraft in North

Fig. 3 A service engineer works with Canadian Air Force personnel during winterization trials on the engine fuel system of a de Havilland Venom.

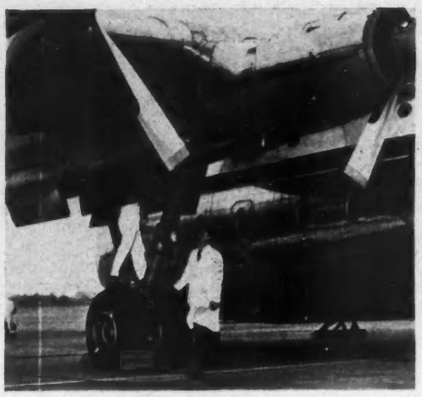


Fig. 4 In a more sufferable climate, a service engineer examines the main undercarriage of an Armstrong Whitworth Argosy.

America, namely, the Viscount, the Britannia, the Comet, the Vanguard, the Argosy, the Caravelle, the Fairchild built Friendship, the Gulfstream, the Canadair CL 44 and the Canadair CL 66. The last five of these are built in the USA or Canada. The Friendship is a source of pride in the Dowty Group for it is understood that no other manufacturer outside the USA has yet supplied undercarriages for USA built aircraft.

It is not only in the geographical width of its activities that the service department promotes customer satisfaction and safety, but also in the fact that it operates around the clock—a feature which is absolutely necessary, of course, because both civil and military trials and operations take place continuously.

When a hitch occurred during accelerated stop trials on prototype aircraft recently, the service engineer present telephoned the service manager at 3 o'clock on a Sunday morning. By 8.30 a.m. a meeting had been convened at head office with the design team, and instructions had been telephoned back to the service engineer on the job.

AOG PROCEDURE

A similar procedure is adopted when an AOG signal (an emergency signal when an aircraft has been grounded and must have immediate attention) is received from an airline operator. When it is necessary on these emergency occasions for an engineer or equipment to be flown out immediately, this can be done in the group's own DH Dove aircraft piloted, appropriately, by a former world air speed record holder, Mr. Neville Duke.

More often, of course, where a service engineer is on the spot he is able to take or advise upon immediate action to remedy any trouble. Sometimes the trouble is simply that the equipment is being misused, but since all Dowty service engineers possess that status symbol among practical engineers, the inspector's stamp, they are able to embody any modifications themselves and thus reduce lost flying time to an absolute minimum. Engineers in the field are kept fully informed of the latest modifications and it has been known for those based at contractors' factories to introduce new modifications on the production line in the middle of a contract.

Similarly, those based with airline operators are kept in the picture about modifications being made to aircraft under construction. A service engineer working at London Airport spent ten days at the Sir W. G. Armstrong Whitworth factory at Coventry to familiarize himself with the latest developments in Dowty Rotol components for the Argosy before that aircraft was delivered to the airlines.

As already mentioned, the function of the service department does not end with the deploying of engineers to assist customers in setting up service installations or in trouble shooting. There is a two-way traffic in information between the department and the individual engineer in the field. The service engineer is the man with the greatest practical knowledge of the aircraft he is servicing and his feedback of data on operating efficiency is very useful indeed to the design and research departments and to the technical authors. On those occasions when the designers recall aircraft components from operation to analyse their reaction to particular types of operating conditions, it is the service engineer who makes the appropriate arrangements in the field.

Every week, all service engineers report to the service manager on the condition and efficiency of the components they have been servicing. They also report back on any changes in operating conditions proposed by the users in order that any necessary advice can be given to the user before the change is instituted.

The engineers' reports are processed on Powers-Samas machines to give the service manager a composite picture of the operating efficiency of each type of component. This composite picture is a valuable guide for the design and research departments who are thus able to note trends before they become troubles. It is also useful to the service engineers themselves, all of whom receive copies of their colleagues' reports.

In addition to reports from his own engineers, the service manager is able to obtain details of operating characteristics in different countries and in different climates through the Aeronautical Service Managers' Association. This body, formed six or seven years ago, is a most useful medium for the exchange of experience of overseas markets and service conditions.

As far as possible the department also endeavours to obtain feed back information from airlines where there is not a permanent Dowty service engineer, this being effectively carried out through the airline's engineering department.

Where such an effective liaison is maintained it is often through personnel who have obtained a working knowledge of the group's products at the Dowty service school. Courses are tailor-made to suit the requirements of the personnel attending them and the operating characteristics of the components with which those personnel are concerned. They range from one week familiarization courses at line maintenance standards to more intensive overhaul courses lasting from two weeks to two months.

Currently, courses are available on hydraulic and landing gear for 12 different aircraft types; on propeller and ancillary equipment for 8 different types; and on five fuel systems. During the past six months, 262 personnel have been sent on these courses by civil and military operators and by engine and airframe constructors. A course in progress is shown in Fig. 5.

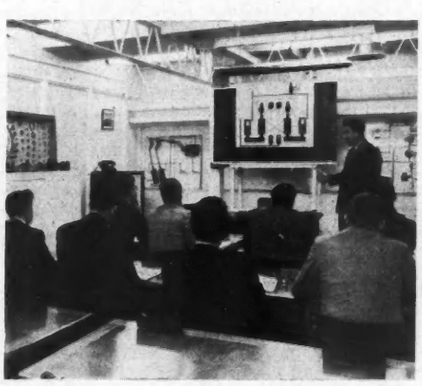


Fig. 5 A group of students receive instruction at the service school.

SERVICING COURSES

Such courses, it must be emphasized, cannot produce service engineers, but they provide operators' staff with a working knowledge that will assist them in recognising minor difficulties and thus reduce to a negligible delay what might otherwise be a major and expensive hold-up. When the Britannia was on its tropical proving flights in Africa a minor fault developed in the hydraulics system. Fortunately, the station engineer present had received instruction at the Dowty service school and recognized that the only action required was the replacement of a small seal.

In 1953 the group augmented its service school by setting up a coach as a mobile lecture and instruction room available to operators. The first task of the mobile lecture room was to provide instruction to 40 officers and NCOs of the Dutch Air Force at the Delen technical training school when the Dutch adopted the Hunter. Similar courses were then laid on for the Swedish, Danish and Belgian Air Forces, and for the RAF in Germany. More recently, tours have been made of Swiss Air Force units.

The service school-trained station engineer or crew chief is indeed an asset to operators in utilising the group's service organization. After he has completed his course he is able to keep in touch with further developments and modifications through the Bulletins and Service Letters issued by the service department.

In addition to his primary duties, the service engineer provides manufacturers and operators with an important service in advising upon the type and amount of spares stocks which should be carried for particular components in particular operating conditions. At spares provisioning meetings between a manufacturer and an operator the advice and opinion of the service engineer is usually a decisive factor in agreeing what spares stocks should be carried. This places a very heavy responsibility on the individual engineer for an operator could all too easily keep several thousands of pounds tied up in unused spares stocks or, at the other extreme, could suffer an equally severe financial setback through loss of flying time caused by a lack of vital spares.

The service engineer also carries out proving trials on installation tools—another example of cooperation with the design department—both at the factories of manufacturers and at the operating bases of civil and military operators.

It is sometimes said (not only by service engineers) that the successful service engineer is born, not made, and it is true that, in addition to a sound technical knowledge, he must have the personal qualities of a diplomat and the ability to make important decisions on his own initiative. Wherever he is working, particularly if it is in one of the remoter places overseas, he is the group's ambassador. In fact, to many operators he is the group, and the group's efficiency will be judged on his personal efficiency and the backing from his department.

On the other hand, his colleagues at home—directors, designers, research workers, metallurgists, production staff and technical writers—use his reports for knowledge of the customer and of the product in use. That they appreciate his importance in this respect is demonstrated by the popularity of the service department's annual gathering at head office.

Pulsed Neutron Techniques

NEUTRON pulsing is a concept that has made rapid advances during the past three years. The advantages gained over the more conventional use of the steady state source are numerous, and the greater versatility outweighs the higher initial capital outlay. The accelerator may be applied to many problems including those in conjunction with the sub-critical assembly, and provides a useful experimental tool in the laboratory.

Neutron Production

Tritium is the heaviest of the hydrogen isotopes and is manufactured by irradiating lithium when the following nuclear reaction occurs:

$$Li^6 + n = He^4 + H^3$$

The tritium produced is readily absorbed by titanium and if a tritiated titanium target is bombarded with a beam of deuterons a neutron is produced. The nuclear reaction involved being:

$$H^3 + H^2 = He^4 + n$$

The great merit of such tritiated targets is that an abundant source of high energy (14 MeV) neutrons can be obtained from particle accelerators operating at voltages as low as 100 kV. Commercially available neutron generators, costing about £8,000, have neutron yields of 10^7 neutrons per second for every microamp of beam current and thus are economically competitive with the more conventional radio-active neutron source. They have the additional advantage of requiring no gamma shielding which is needed with large antimony-beryllium neutron sources.

Not so Versatile

The deuteron beam of such generators can be modulated to give short bursts of neutrons from 1 to 1,000 microsecond duration. If such a burst of neutrons is injected into a medium and the transient behaviour of the neutron intensity measured, a surprisingly wide range of parameters of importance in reactor design can be determined, for example, the diffusion coefficients, capture and scattering cross-sections, neutron life-times, neutron age, neutron spectra and reactivity. Pulsed neutron generators have been installed at Queen Mary College and Imperial College, London University, and at Birmingham University, where they are proving of great value as neutron physics research facilities in the absence of research reactors. Also a report by G. R. Keepin (LAMS-2215) illustrates a wide range of experiments that may be conducted by neutron pulsing techniques.

Neutron Diffusion Measurements

It is observed that the neutron intensity following the injection of a burst of neutrons in a non-multiplying medium falls exponentially with time with a decay constant (λ). Thus the decay constant will depend upon the rate of absorption in the medium and the rate of leakage by diffusion through the boundary surfaces. The former rate is proportional to the macroscopic absorption cross-section (Σ_a) and the latter to the product of the diffusion coefficient (D), and a geometrical factor (B^2). B is known as the geometric buckling and can be calculated from the dimensions of the medium being studied. If the decay constant is measured for a variety of geometrics and is then plotted against B^2, as shown in Fig. 1, a straight line is obtained, and the slope gives the diffusion length, the diffusion coefficient and the macroscopic absorption cross section, the absorption cross-section is obtained from the intercept on $B = 0$. Knowing D and Σ_a, the diffusion length (L) may be calculated. In practice a slight curvature is observed due to the preferential leakage of higher energy nuetrons which leaves the equilibrium distribution " cooled " below that existing in an infinite medium. The accuracy of the values obtained by the pulsed neutron technique for the diffusion and absorption coefficients of beryllium by W. H. Andrews (UCRL 6083, 1960) are comparable with those obtained by the conventional exponential experiment, which require greater volumes of moderator and a reactor as a neutron source.

Effect of Varying Systems

In a multiplying medium, for example, one containing fissile material, the neutron intensity persists longer because of the augmentation of the source neutrons by the neutrons arising as a result of fission events. For a just-critical assembly the neutron intensity would persist indefinitely if one ignores the effect of delayed neutrons. It is clear that the greater the reactivity the slower the neutron intensity will decay away. Fig. 2 shows the variation of neutron intensity with time in the Queen Mary College sub-critical assembly.

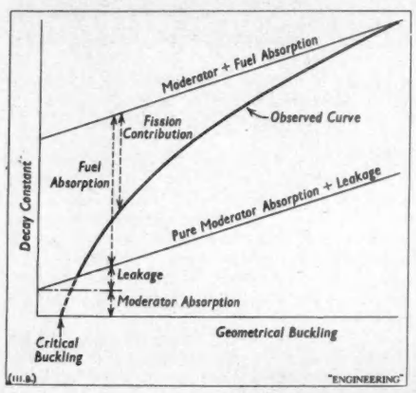


Fig. 1 (above) Variation of decay constant with geometry (size) for multiplying and non-multiplying media.

Fig. 2 Variation of neutron intensity with time.

Pulse Height Analyser

A Sunvic multi-channel pulse height analyser is used as a time analyser and has 70 channels, each 22 microseconds wide. The number of counts received in each channel is recorded on a binary scale vertically. Due to the binary scale, the coordinates are neutron intensity on a logarithmic scale, and time, thus the slope of the line formed by the uppermost brightened digits gives the decay constant (λ) directly. Measurements of λ can be used to determine reactivity changes due to voidages and control rods and also the magnitude of the neutron multiplication of a sub-critical assembly.

Estimation of Prompt Critical

Fig. 1 shows in detail the variation in the decay constant with geometric buckling in a multiplying medium. For a moderating material the decay constant depends on the absorption and leakage, the absorption term being greater for the multiplying medium because of the fuel absorption. The effect of fissions in the fuel is to reduce the value of λ by an amount which depends upon the probability that a fission neutron will be thermalized in an assembly having buckling B^2. An extrapolation of the λ versus B^2 curve to the value of B^2 where $\lambda = 0$ enables the prompt critical buckling and hence critical size to be determined, small values of B^2 corresponding to large geometrical dimensions. A determination of λ for a delayed critical assembly gives directly the prompt neutron lifetime if the value of the delay neutron fraction for the system is assumed.

Neutron Spectra Applications

By using very short bursts of neutron, less than 1 microsecond, neutron spectrum measurements may be performed. Basically these consist of injecting a burst of neutrons into an assembly and displaying on a time analyser the neutron received from a particular region of the assembly at a distance of 10 to 100 meters from it. Due to the difference in the time-of-flight of the neutrons travelling down the flight path, neutrons of different energies may be distinguished. Such investigations require extremely high intensity bursts of neutrons which are available only from high energy accelerators used in conjunction with a " neutron booster "—this consists of a near-critical assembly of enriched uranium. Investigations into this problem are being made at the Atomic Energy Establishment, Harwell, and in the United States.

Assistance in Fast Reactor Calculations

The pulsed neutron method has also been successfully applied to measurements on fast reactors where the technique forms a useful complement to the Rossi-α technique, since it is easily adapted to systems below delayed critical. The technique requires fast electronic instrumentation because the decay periods are in the milli-microsecond range.

New Euratom Contract

A contract for cooperation promoting experimental and theoretical research into controlled thermonuclear fusion has been concluded between the European Atomic Energy Community (Euratom) and the Plasma Physics Institute, Garching, near Munich. The contract will cover an initial period of three years at a total cost estimated to be DM 30 million (£256,000). Euratom will provide 33 per cent and the Plasma Physics Institute 67 per cent. As soon as the laboratories have been built at Garching, about 80 scientists and engineers will be employed there. Euratom is already participating in two other fusion research contracts (Atomic Review, 17 March '61):

(1) With the French Commissariat à l'Energie Atomique. Under the terms of this contract 104 scientists are working at Fontenay-aux-Roses.

(2) With the Italian Comitato Nazionale per l'Energie Nucleare (CNEN). Some 60 scientists are employed at Frascati on research work.

Companies

Tough Going in Heavy Plant

No early return to a better profit level for the heavy plant industry is forecast by Sir Kenneth Hague, the Babcock and Wilcox chairman. He is, however, able to assure the company's stockholders in his annual review that the steps taken to reshape the productive capacity of the company to meet contemporary demands will be increasingly to the advantage of the total capital deployed at home and abroad.

The final Babcock and Wilcox consolidated net profit for 1960—£641,436, was only slightly higher than that earned during 1959—£573,850. That the consolidated profit for last year was of this order, on a total income of £35,673,000, is a strong indication of the tough going in heavy plant. Materials swallowed up £15·4 million of the total income, wages and salaries another £11·4 million and employee benefits £5·5 million.

Sir Kenneth points out that although the consolidated profits were only a little higher an exceptional amount of nuclear work has had to be absorbed in the accounts of the parent company for 1960 and there was nothing quite as severe as this during 1959. Development work to meet the exacting requirements in manufacture for the Hinkley Point and Trawsfynydd nuclear power station contracts and the "unprecedented" labour problems on site, which were mostly outside the control of the company, have proved most expensive.

On these contracts the company made a loss during the year of £650,000. Provision has also been made of £700,000 out of the existing Contingencies Reserve for further losses which may be met on these nuclear contracts before their completion. The financial strength of Babcock and Wilcox is such that while this has been going on the value of the net current assets has been maintained and the amount of bank overdraft substantially cut.

Capital Savings

Among installations completed for the Central Electricity Generating Board were the large oil-fired boilers at Plymouth power station, the 860,000 lb of steam per hour units at Blyth, Northumberland, and Rugeley, Staffordshire. Four more similar boilers are being built for the Rugeley power station.

Contracts in hand at the end of the year were a little higher than 12 months earlier. While labour, raw materials and services all cost more, the general price level of boiler plant is much less than it was ten years ago. Improvements in boiler design and in the overall installation costs have made possible this substantial capital saving to the customers.

The profit margins left after these developments are in general insufficient when the considerable technical risks of design, manufacture and erection are borne in mind and when allowance is made for fulfilment of contract guarantees demanded.

In the home market the largest single order ever received by the company came from the CEGB, for four boilers, each with a 500 MW capacity, for a coal fired power station to be sited in the Midlands.

Overseas the widespread Babcock and Wilcox associated and subsidiary companies received some important orders and made progress varying from steady to excellent. The going was not so good in Brazil, where Babcock and Wilcox (Caldeiras) SA found that prices being obtained for boiler plant made to their normal standards were inadequate to cover normal operating expenses. Even if manufacture in the territory should have to be shut down completely, the group has no intention of abandoning this market. The Mexican company is not yet gaining profitable trading results but orders on hand are much greater than a year ago and future prospects are encouraging.

Higher Turnover Lower Profits

The engineering division of Newton, Chambers and Company reached the highest turnover of its history last year but the profit margin fell below that of 1959, due to the more complicated and diverse nature of the work being carried out. For the gas industry three tower purifier contracts and the first high pressure purification plant at Westfield, Fife, were completed.

Increased orders from the steel industry and from chemical engineering offset to some degree the further decline in orders from the gas industry. The engineering division was working closely with the Ransomes and Rapier subsidiary in the production and erection of the large RapieR Walking Dragline excavators for the open-cast mining or coal and iron ore.

Record turnover, almost fifty per cent for export orders, was also reached by the excavator division, through the London based sales company, NCK-Rapier Limited. The division worked at a very high level throughout the year meeting a heavy demand for its range of machines.

A heavy programme of capital expenditure over the past five years has involved the spending of more than £3 million on new buildings and plant. At the same time selling arrangements, particularly overseas, have been rationalised, putting the company in a better position to take advantage of any increased demand either for capital investment or in the consumer market.

Part of the group's contact with consumer demand is through its chemicals division and the newly acquired subsidiary Ronuk Limited, of Portslade, Sussex, a household name in polishes.

Ransomes and Rapier Limited present an interesting situation. Their turnover in 1960 was the highest yet obtained, but as with the engineering division, the profit showed a drop below the previous year. The principal contributory factor came from the first sale abroad of a large walking dragline. In order to meet fierce foreign competition a low price was accepted. Since it was the first to be exported and had to operate under conditions entirely different from those met by machines working in the United Kingdom, special measures were taken with consequent increase in the manufacturing costs.

After this experience the directors have felt it advisable, says Sir Peter Roberts, M.P., in his chairman's annual statement, to make a special provision of £75,000 against contingencies on this contract.

Promising Outlook in Soviet Expansion

So far as can be reliably predicted, the pattern of Soviet economic development in the foreseeable future seems likely to be one of continued massive effort in capital investment in industry, accompanied by varying degrees of attention to raising the standards of the consumer-citizen, whether urban or rural.

Many of the companies exhibiting at the British Trade Fair in Moscow are well placed to increase their trade with the Soviet Union in both directions; none more so than Automatic Telephone & Electric Limited, of Liverpool.

The very full and representative stand presented by ATE covers their activities through the development and manufacture of automatic telephone equipment, telephone and telegraph transmission equipment for line cable and radio links, supervisory remote control systems, road traffic signals and special signalling systems for mines.

Much of the equipment shown is for public telephone networks. One of the latest developments in this field, an automatic telephone exchange employing a new simple method of crossbar control (*inset*) is represented by a highly accurate and detailed scale model of an exchange in operation at the company's main factory. Some of the crossbars used in the system are being shown.

An ATE development that may be of wide interest in many parts of the Soviet countryside is the vhf radio telephone, the Country Set. Using this equipment it is possible to give telephone service to anyone who is isolated by natural obstacles that cannot be bridged by wires or cable but is within vhf range of an exchange. For the purposes of the demonstration it will be shown working into a small automatic telephone exchange. The remote subscriber's pole-mounted transmitter/receiver provides full dialling and signalling facilities. Battery operated, the Country Set is designed in such a way as to keep battery consumption down to a minimum.

This type of equipment, and the telephone exchange gear in general, will be more and more needed in the Soviet Union as the standards of living rise, and it is a reasonable assumption that while there is indigenous manufacture in the field there is equally an opportunity for such companies as ATE to stake out a share of the market using the most advanced equipment and striving for the most favourable prices.

More strictly related to industrial reequipment and expansion is the Inductorpohone, a telephone system enabling communication to be established between any two points several miles distant from each other. On the ATE stand this is to be demonstrated using the stand's metal handrails as a conducting path.

The Inductorphone is able to operate over metallic conducting paths provided by existing signal wires, pipes, the armouring of power, lighting or telephone cables, or railway tracks. This system can be used where normal communication methods are impracticable or uneconomic. One example of this is between the pithead at a coal mine and a moving cage in the shaft, or a moving locomotive underground.

From a wide range of equipment developed for use in mines, ATE is demonstrating a signalling system for controlling the indications associated with the raising and lowering of the cage in the mine shaft. By eliminating the business of impulse signalling by hand the system reduces the possibility of conflicting signals.

In the electricity and gas industries, on the railways and elsewhere, ATE is known for its developments in remote supervisory and control equipment. For the Trade Fair, the company is showing a new standardized type of supervisory remote control and indication system to enable potential users to obtain a system which meets their requirements but needs no elaborate engineering.

Increasing Capacity in Bearing Production

For the Hoffmann Manufacturing Company the fall off in the consumer industries' demands for their bearings in the latter half of last year was to some extent compensated by an increase in sales on the capital goods side of their products. Now the consumer industries' demand is coming back again and the activity in capital investment is maintained.

Shortage of skilled manpower is given by Mr. J. W. Garton, chairman and managing director, as the limiting factor in the company's expansion. This is being alleviated as the training schemes which have been run by the company for some years produce young people trained for jobs varying from the shopfloor to management.

Heavy spending has gone into new plant and machinery at the Chelmsford and Stonehouse works. Although this machinery was mostly not ready for production until too late in the year to make any serious impression on the results since the beginning of the year it has been doing "very well indeed." Hoffmann, like other companies, is engaged in an active pursuit of increased efficiency in order to meet rising costs of material and a greater wage bill.

More than £1 million was spent on increasing capacity during the year. Capital commitment at the end of last year stood at £400,000 and additional investment has been authorized, particularly the building of a new factory at Gloucester in order to extend production capacity.

Foamed Glass—A Load-Bearing Insulation

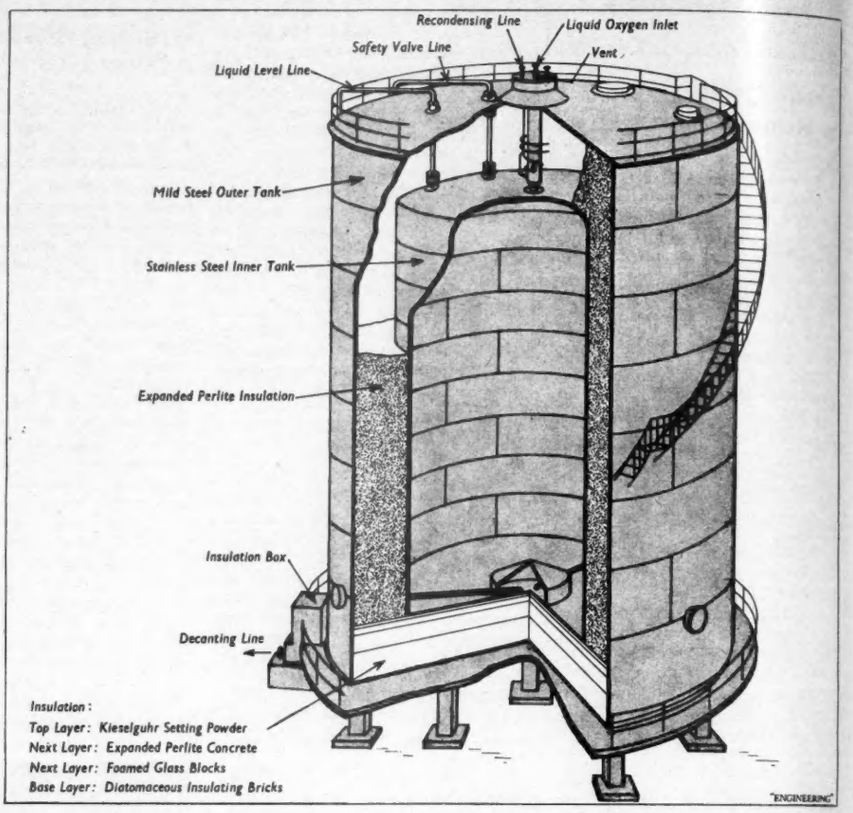
Foamed glass is an imported insulation material. This article describes three uses in the UK. All exploit its load-bearing properties and one its impermeability to vapours.

THE number of load-bearing insulation materials is not large. The most obvious are diatomaceous lightweight bricks, asbestos board, cork, strawboard, expanded aggregate or aerated concrete, foamed plastics such as Onazote and foamed phenolic, or beds of insulating powder. There is also a product made by foaming glass. This article is primarily about uses in Britain of the last of these—Foamglas, made in America by Pittsburg Corning, and imported and sold in this country by William Kenyon and Sons (Thermal Insulations).

One of the most difficult load-bearing insulation problems is for low temperature storage containers for liquid gases. These are currently causing some thought in connection with bulk storage of liquid methane and oxygen. For liquid methane, two tanks were completed last year on Canvey Island. This liquid is stored at — 196° C. The load-bearing insulation for the inner tanks was diatomaceous insulating brick with a facing and with sealers. Expanded perlite insulation was placed between the vertical walls.

With liquid oxygen at — 183° C, problems of insulation are similar to those for liquid methane, but there is the added danger of spontaneous combustion of organic materials in contact with spillage. This would generally rule out use of many of the insulation materials mentioned in the opening paragraph.

It is now possible to record the method used by British Oxygen Engineering in construction of a land-based storage tank for liquid oxygen at the Westfield high-pressure coal-gasification plant. The cutaway diagram shown above is based on one which appeared in the Institution of Gas Engineers' publication No. 567 which is a description of the whole Westfield project by Mr. T. S. Ricketts, chief engineer of the Scottish Gas Board. Insulation which bears the weight of the inner tank is a four-layered structure; at the bottom is a 3 ft depth of porous diatomaceous insulating brick. On top of this are five courses of 4 in thick Foamglas blocks with sealants to a total thickness of 1 ft 8 in. Above this is a 5 in thickness of expanded perlite concrete and immediately next to the inner tank is a half-inch thick layer of Kieselguhr setting powder. Each layer was sealed so that it was protected as the job proceeded.



Foamed glass, 20 in thick, form part of the base insulation in this liquid oxygen container.

The tank itself will contain the equivalent of 15 million cu. ft of oxygen which in the liquid state weighs 560 tons. The inner tank is 25 ft diameter and is made from welded austenitic stainless steel. The insulating base and the inner tank are within a mild steel outer shell of 35 ft diameter and the whole is carried on a reinforced concrete base raised 5 ft above ground level on reinforced concrete columns.

The space between the inner and outer walls is thus 5 ft across—the same as the overall thickness of the base—and is filled with expanded perlite made by Expanded Minerals under the name Brelite.

The interesting aspect of this design is in the choice of load-bearing insulation. When the container is full of liquid oxygen, the load is about 1·3 tons per sq. ft, which is demanding on a structural insulation.

The Foamglas variety of insulation is made in America. A Czechoslovakian product which is reputed to be cheaper is being tested by at least one firm in this country. Foamglas is imported by William Kenyon in 24 in by 18 in by 5 in blocks with a density of 9 lb per cu. ft. This is cut to several standard sizes and is currently being offered at a standard price of about 1*s* 10*d* per board foot—or about 22*s* per cu. ft. William Kenyon also cut pipe sections from block and these are available to cover pipes from ½ to 22 in diameters.

Compression strength of the foamed glass is quoted by the makers as 100 lb per sq. in, so with its thermal conductivity of 0·35 Btu per sq. ft-hr-°F per in at 0°F, this material is truly a structural insulation. There is no lower temperature limit, but William Kenyon comment that it is best to avoid too sharp temperature gradients which under bad circumstances can cause cracking in the blocks.

Laying blocks of foamed glass in bitumen on the roof of the Ariel Hotel at London Airport.

Pores in the foamed glass do not interconnect, so that the insulation does not permit water vapour to pass through it. It should be recognized, however, that a vapour seal will still be needed between the blocks when the insulation is used for low temperature containers. Atlas Preservative Company are licensed in the United Kingdom to produce a range of adhesives, sealers, bedding compounds and coatings which are intended for this purpose.

Other uses of Foamglas in the United Kingdom are small in number compared with those in America. The left hand illustration shows the material being laid on the roof of the Ariel Hotel near London Airport. This insulation was bedded in bitumen and covered with asphalt. Russell Diplock Associates write that they specified this material—and 20,700 sq. ft in 18 in by 12 in by 1½ in pieces were actually supplied—because, in their words, "moisture does not affect it; it is a stable material which will not deteriorate; it has very good thermal insulation qualities, is light and does not increase the dead load on the roof."

A further use of foamed glass is as backing for infill panels in curtain wall construction. Thus Edward Curran Engineering offer their Seaporclad porcelain enamelled infill panels with several insulation backing materials, and one of their specifications is for panels with foamed glass insulation. It appears that these were recently supplied for the new Boots Chemists factory at Nottingham.

Atlas Preservative Company Limited, Erith, Kent.
British Oxygen Engineering Limited, Angel Road, Upper Edmonton, London N18.
Edward Curran Engineering Limited, Cardiff.
Russell Diplock Associates, 235 Vauxhall Bridge Road, London SW1.
William Kenyon and Sons (Thermal Insulations) Limited, Dukinfield, Cheshire.

Sprayed Material Displaces Moisture

An American formulation which can be used to displace water from solid surfaces is now being marketed in this country by Hellerman Limited. It is a product of Corrosion Reaction Consultants and is called CRC2-26.

The makers do not reveal what the basic compound is, but from their published literature it seems to remain a thin liquid film when applied to solid surfaces. This film is claimed to act as a corrosion preventive as well as increasing the surface resistance for electrical components. The ability to displace moisture is explained by the very low surface tension of the liquid. It is claimed of this material that it can be used to restore to operation, equipment that has been damaged by excessive exposure to moisture or by total immersion—referring of course to electrical components.

Hellerman are offering this in the form of an aerosol pack but it is also available in 1, 5 or 55 gallon containers.

Hellerman Limited, Crawley, Sussex.

Ship Converted with Asbestos Board

MS "Kuala Lumpur," of 12,555 gross tons, was formerly the troopship Dilwara, and is now owned by China Navigation Company. It recently underwent a major conversion at the Taikoo Dockyard and Engineering Company of Hong Kong.

Built in 1936, the Kuala Lumpur was converted in the space of three months to meet the latest regulations of the Ministry of Transport governing passenger ships, covered by the Merchant Shipping (Construction) Rules, 1952.

As the Kuala Lumpur had no sprinkler system installed, the owners decided that the best method of conversion was to Method I, which stipulates that in addition to A Class fire resisting divisions, B Class divisions of non-combustible materials are to be used in all accommodation and service spaces, in addition to an automatic fire alarm and fire detection system.

Turners Asbestos Cement Company say they were selected to supply some 100,000 sq. ft of ships' board panels for forming A and B Class linings, included in which were some 115 B Class door assemblies. Wherever possible, panels were prefabricated at Turners Asbestos Cement Company's Trafford Park works to facilitate speedy erection. The majority of B Class panels and doors were faced with decorative Formica plastic, and ships' board panels for A Class divisions were supplied faced with $\frac{1}{16}$ in Turnall asbestos cement veneer sheet. Ceilings generally were of $\frac{1}{2}$ in Turnall asbestos ships' board, primed for painting.

Turners Asbestos Cement Company Limited, Trafford Park, Manchester 17.

Pvc-Coated Steel Clads Sugar Diffusers

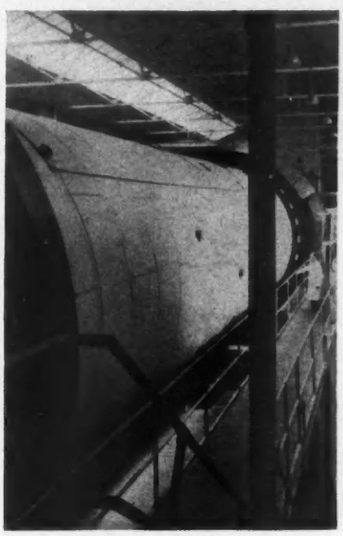
What can a firm do to keep its equipment smart and colourful when this is often on view to visitors? British Sugar Corporation were faced with this thought—and decided two years ago that it would be worth trying Stelvetite pvc-coated steel instead of having to repaint at regular intervals.

The pieces of equipment for which it has now been used on three occasions are sugar diffusers. In these 17 to 22 ft diameter by 100 ft long rotating drums, sugar beet pulp moves in an upwards direction under the action of radial fins, while hot water flows in a counter-current manner under the force of gravity. Sugar is thus extracted.

British Sugar Corporation's factories at Kidderminster, Ely and Allscot are the three places where pvc-oated steel has been tried; and it was in the first of these that the main emphasis was on good looks. At Ely, where the clad diffuser has now been used for two years (it was the first chronologically) Stelvetite was used mainly to counter corrosion—as the atmosphere in the factory is very damp. Aluminium and painted aluminium had corroded badly in previous experience.

In construction of these diffusers, the cladding material is fixed with wooden spacers and rock-wool insulation between it and the inner drum. In all three instances, there are various hatches and take-off points along their length, but there is no particular problem of leakage or attack from these sources.

In the Ely installation, pvc-coated steel panels



in light green with a pin-point "seal" finish were simply overlapped like forerunning aluminium sheets and were fixed to wooden spacers by PK screws. No edge protection was provided on horizontal seams, but aluminium strips were placed over circumferential ones. Although resisting corrosion over the larger parts of the panels, some rusting did occur at panel edges. With this experience behind them, BSC constructed the diffuser cladding at Kidderminster in a different manner—using tight-fitting aluminium extrusions so as to give a picture frame structure. Pop rivets were used to fix the cladding to wooden spacers. The finish at Kidderminster is white with "tweed" finish; at Allscott, it is the same colour with "morocco" graining.

BSC think, from the few months during which this diffuser (shown here) has been operating at Kidderminster with its Stelvetite cladding, that the picture panel construction is going to be satisfactory. Six diffusers destined for export to Russia are being similarly fabricated.

British Sugar Corporation Limited, 134 Piccadilly, London W1.

John Summers and Sons Limited, St. Ermins, Caxton Street, London SW1.

Pvc-Coated Steel and Copper Coatings

A new version of the Sadia electric water heater has now gone into production at the newly opened Salisbury factory of Aidas Electric. This company has several very forward-looking ideas in choice of materials and production techniques. Thus, the top and bottom pressings and side panels of this heater are made from pvc-coated steel—Stelvetite made by John Summers. This has eliminated the need for building a paint shop in the established factory and John Summers estimate that a saving of 17½ per cent on capital cost has been effected.

Unfortunately, such simplification does not necessarily tell a true story. Stelvetite costs about three times as much as the equivalent steel sheet and the cumulative effect of having to pay around 6*s* premium for the elimination of painting on each heater adds up to a great deal when multiplied by the annual output of 67,500 units which the company eventually hope to achieve from this plant.

Production engineers from the parent works of Aidas have concluded that "at the worst, the overall cost will be the same as for the enamelled version" but there have been one or two difficulties to overcome even before operations could commence to prove this. For instance, it has been necessary to change the design of the bottom pressing which used to have a number of lugs

spot-welded on to it. Although it is possible to obtain equipment for spot welding pvc-coated steel with both electrodes on one side of the sheet, Aidas comment that the equipment costs about £1000 and that the electrodes have to be too close to enable them to get to difficult places. Thus they have resorted to integral lugs and rivetting. A further difficulty appeared in the form of rubbing marks during pressing operations. The modification work on dies needed to eliminate these delayed starting up the press line for about a month, and the bottom pressing could not be called complex.

Despite these drawbacks, Aidas express confidence in their decision to use Stelvetite and certainly the finished article looks attractive. Time will prove whether the economics are sound and whether the pvc coating stands up as well as or better than normal alkyd stoving enamels used on other models.

In another part of this new factory, Aidas make large numbers of immersion heating elements. In order to prevent formation of verdigris on the copper elements before they are put to use by the customer, Aidas spray them with a resin-bound metallic copper stoving compound. A director remarked that the overspray losses of at least 90 per cent when air-spraying these tubular elements are in his opinion the worst part of the whole plant. But his research team is on the brink of solving this. To start with, Henry W. Peabody, who sell electrostatic spraying equipment, have said that they can now spray metallic paints (which has been thought impossible up till now). Alternatively, Aidas are experimenting with a mist chamber with paint recovery into which the elements would be "dipped." Normal dipping is impossible because of severe settlement in the paint and its unfavourable flow characteristics.

This company already have experience with electrostatic spraying, for it is used to apply zinc chromate rust-resisting stoving primer to all steel components at their other factory.

Aidas Electric Limited, Rowdell Road, Northolt, Greenford, Middlesex.

Sensitive Manufacture of Instruments

Instrument manufacture is one of the fields in which the aircraft industry has opened up new possibilities for other industries. Originally built for guided missiles, the Miniature Integrating Gyroscope now has many other applications.

THE Instrument Wing of English Aviation Limited, a branch of the British Aircraft Corporation Limited, is housed in a factory at Stevenage, Hertfordshire, which is said to be cleaner than an operating theatre and where work more skilled than that of the expert watchmaker is an integral part of the production process. This £1 million factory was designed and built as part of a comprehensive and long term plan for advanced research into, and production of, highly specialized instruments which are finding uses in various fields of industry.

Indeed, this is another example of the high standards of precision and automatic control developed in the aircraft and allied industries opening up new possibilities in quite unrelated industries. At present about 40 per cent of the Instrument Wing's production is for two of the British Aircraft Corporation's principal guided weapons, Blue Water and Thunderbird, which are also produced at Stevenage. There is a rapidly increasing tendency, however, for the technique used in the production of infinitely accurate gyroscopes and other missile guidance equipment to be adopted in the development of equipment for mining, surveying, the manufacture of steel and electrical goods, long-range pinpoint navigation by sea, air and in space, and electronic computers.

The Instrument Wing was set up two years ago for the manufacture of complete guided weapons systems. Previously, relatively simple and large displacement and rate gyroscopes were developed and produced for Thunderbird, the army's ground-to-air missile. When development of the Blue Water missile was ordered for the army, it was decided to take out a licence with the Minneapolis-Honeywell Regulator Corporation of the USA for the manufacture of their seven-ounce miniature integrating gyroscope, the MIG. This gyroscope, which is the only miniature inertial quality gyroscope made in Europe, is based on the floating principle conceived by Dr. Draper, of the Massachusetts Institute of Technology, to remove friction error.

The beginning of work on the MIG coincided with BAC's decision to expand the Instrument Wing into a factory with the most advanced and comprehensive facilities for this type of work in Europe. To do this, it was necessary to provide (*a*) an area for making piece parts to tolerances down to millionths of an inch; (*b*) an area for assembling these parts in conditions of greater cleanliness than ever before; and (*c*) an area for the testing and examination of the end product.

The first of these requirements, the making and machining of piece parts, demanded production equipment of original design and conception. In other cases, conventional tools and equipment had to be modified to provide greater accuracy. The de-burring operation in Fig. 1 is typical of the detail work involved in making the piece parts.

Inspection of these piece parts was also a difficult problem and the instruments used in production inspection in the temperature controlled measuring rooms are of a calibre more usually seen only in experimental laboratories and standards rooms.

STRICT AIR CONDITIONING

Dust is excluded from the assembly rooms by filtering the clean country air as it enters the building. Particles of dust larger than 0·1 microns—that is, one ten thousandth of a millimetre—are removed. The temperature of these assembly rooms is kept at a comfortable 72° F and humidity at between 35 and 45 per cent.

A further cleanliness check is that personnel entering the assembly building wear nylon smocks and caps and those working in the area of highest cleanliness make a further change into special clothing and anti-static boots. In addition to wearing this special clothing, the workers concerned receive intensive training in the important contribution made by personal cleanliness.

Figs. 2 and 3 give an idea of the tremendously accurate and demanding nature of the assembly work. The latter illustration is particularly interesting as it shows how the final assembly operations are carried out in a positive pressure cabinet in which super-clean air is continually pumped over the operator's hands to prevent invisible dust particles from settling on the work.

Once assembled, the instruments are extremely sensitive and special precautions have to be taken to ensure that they are isolated from all vibrations when under test. Vibration caused by high winds is reduced by the fact that the whole factory is a single storey building, and all moving machinery, including the air conditioning and air cleaning plant, is at least 80 ft from the factory and all connections for air filtration and control are by flexible overhead ducts.

All other sources of vibration—such as express trains on the railway a quarter of a mile away, footsteps in the corridors and traffic on the projected Stevenage by-pass—are excluded by testing the instruments on concrete plinths attached to 50 ton concrete blocks supported on inflated rubber bellows. Below the rubber bellows are further large blocks of concrete embedded deep in the foundations.

The performance of accelerometers under known conditions of acceleration is measured to a few parts in a million on a special centrifuge which rotates on an air cushion above a slab of solid granite, the central bearing being air lubricated. Driving torque is provided by tangentially mounted air-jets to eliminate the friction inherent in mechanical drives. An instrument system monitors the speed of rotation and the change in radius of the centrifuge arm.

An example of the type of system made possible by using these new techniques is Precision Indication of the Meridian, known more briefly as PIM. This exploits the extreme sensitivity of the floated rate integrating gyroscope to detect North within half a minute of arc—it is likely that this will be reduced to about 15 seconds of arc—by sensing the horizontal component of the earth's rotation.

The PIM system has been developed primarily for the War Office for aligning field artillery and tactical guided missiles in the dark or bad weather, or where there are no known survey points. However, interest has also been shown in this system for survey work in mines and tunnels where normal visual and astronomical methods are not practicable.

In addition to the development of advanced production techniques essential in the manufacture of high performance instruments, it has also been necessary to design and develop a wide range of production test equipment. One such item of equipment is the IFG 106 which is capable of carrying out a wide range of tests on a rate integrating gyroscope. It is now in production by the Instrument Wing for a ready market.

Another interesting item of inspection equipment is the Direct Reading Permeameter which is claimed to be the only device of its kind in the world for obtaining instantaneous readings of component material permeability. It provides a quick and accurate means of checking laminations or subassemblies of high permeability materials.

Thus, a factory which was built for a highly specialized and circumscribed purpose has turned out to have an important relevance to other, sometimes quite different, industries. Seeing this opportunity, English Electric Aviation are making their Instrument Wing available for work on behalf of outside interests.

Fig. 1 An instrument is deburred under a microscope of 30 × magnification.

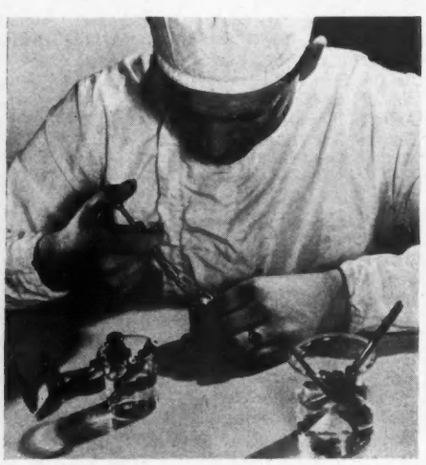


Fig. 2 Applying epoxy resin cement to a gyroscope assembly with a hypodermic syringe.

Fig. 3 Assembling a MIG gyroscope in a super-clean cabinet from which all dust is excluded.

Russian Journal on Castings Production

Another Russian technical journal is to be translated under the sponsorship of the Department of Scientific and Industrial Research. The British Cast Iron Research Association is undertaking the cover-to-cover translation of the Russian monthly, *Liteinoe Proizvodstvo*, under the title, "Russian Castings Production."

All aspects of castings production are covered by this journal, from raw materials through melting processes and equipment, moulding sands and methods, casting and fettling, to the service behaviour of the end product. The emphasis is on cast iron and steel castings, but there are also articles on non-ferrous and, particularly, light alloy castings.

In addition to covering day-to-day problems in foundry practice, the journal deals with papers on new techniques and on metallurgical investigations by Soviet technical institutions. The translation will normally be published four months after the original, the first translated version being due to appear this month.

Further information is available from the Publications Officer, British Cast Iron Research Association, Bordeslye Hall, Alvechurch, Birmingham.

First On-Line Digital Computer

What is stated to be the first digital computer for the on-line control of an industrial process in this country is now in operation at the Stocksbridge, Yorkshire, steelworks of Samuel Fox and Company Limited. The introduction of this computer to line production represents a major advance in automatically controlled production, and it is likely that this system can be adapted for use in other types of industry. It has been made possible by close collaboration between Samuel Fox and E-A Automation Systems Limited, a member of the Elliott-Automation Group, who have installed the computer.

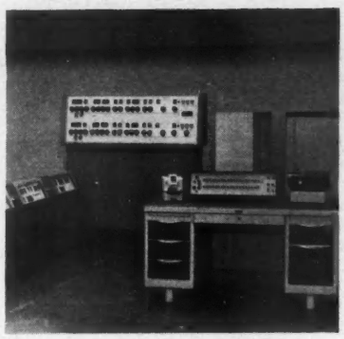
In this steelworks, billets of high quality steel are rolled to lengths of up to 450 ft and are then cut to customers' requirements. The basic problem is to cut the billets to produce minimum wastage of this valuable product within the limits of the customer's specification and the length finally rolled. There are four aspects of this central problem, namely (*a*) measurement of billet length, (*b*) calculation of optimum cutting points, (*c*) transmission and display of this information to operators, and (*d*) recording of data for office purposes.

The first premise on which the Samuel Fox and E-A Automation Systems engineers worked was that the solution lay in the use of a digital computing system. On the scale of this works a digital computer gives more flexibility—an important feature since customers' orders vary greatly—than an analogue computer. Further, the computation had to be fast enough to avoid delaying billets on the track, so that a self-calibrating length measurement system was needed and, since a number of billets can be on the track at the same time, capacity for the storage of information was also necessary.

Having decided that there was sound economic justification for introducing a computer, a system was designed to include the Panellit 609 Information System which incorporates the Elliott 803 general purpose computer. Thus this first on-line computer control system is based on standard computer equipment.

The first part of the problem, the measurement of length, was solved by a self-calibrating pulse-counting system which compensates for the wear on the mill rolls and also for contraction of the billet length when cold.

In operation, the customer's order is first set on a panel, shown in the centre of the illustration, by the Mill Foreman, the object of this method of input being to maintain the personal responsibility of the foreman. The order may specify for the final billet a fixed length, a limited



Equipment for the computer control system. On the left are the operators' display panels; in the middle at the back is the console on which customers' orders are set.

continuous range or a range consisting of a series of stops. The computer calculates the optimum cutting points, allowing statistically for the variability of the stops at each saw and shear, in less than a second and this information is then stored in the computer for the use of the operators in setting their shears.

Each operator has a display panel (on the left in the illustration) on which information relating to the billet about to be cut up is displayed when a demand button is pushed. Checks are provided in the computer to ensure that the billet being cut is the correct one.

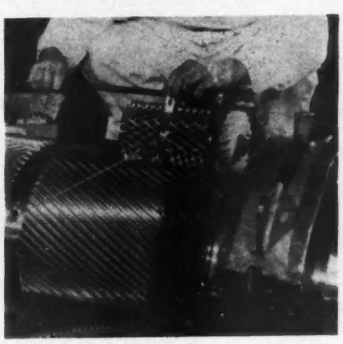
An advantage of the stored programme of the 803 computer is that changes in mill or system operation can be incorporated at any stage of the design after the system has been installed.

The manual operations retained in Samuel Fox's system can be replaced by automatic links later, if necessary. Indeed, the introduction of the in-line computer is virtually an advance making possible (or, anyway, foreseeable) a fully automatic mill.

Adjusting Gear Tooth Contacts *in Situ*

A method of attaining a higher degree of perfection in the manufacture of large precision gearing—particularly marine gears—was recently demonstrated by the De Laval Ljungstrom Turbine Company of Sweden. However accurate production methods might be in a gear works, there still remains the influence on gear alignment and tooth contact of actual operating conditions. In this way, a perfect gear on the shop floor can become an inefficient gear on board ship.

After considering hand dressing and other manual methods for adjusting such faulty gears, De Laval have developed a honing device which, although it cannot correct pitch errors or undulations caused by bad gear cutting, can often produce a perfect tooth contact by honing off minute amounts of steel from the tooth flanks where the contact is too hard. This prevents pitting or any other surface fatigue in the teeth caused by misalignment.



The honing device being applied to a marine gear.

The honing action, which is normally applied to the pinions, is entirely uniform on each tooth around the whole circumference. A great attraction of the device is that it can be used with the gear still *in situ* and, since the process normally takes no longer than 15 to 20 hours, can usually complete its task inside a normal port call.

As shown in the illustration, the device consists of an oscillating plastic wheel with the same pitch and other characteristics as the gear to be treated, and carried by a toothed steel roller in mesh with the pinion. As the gear turns, the machine travels slowly along the axis.

The actual honing is by means of a grinding compound which is applied to the surface to be treated. The amount of honing necessary is decided by visual inspection of the tooth surfaces, which can be gauged by an expert eye from uniformity of alignment.

De Laval are represented in this country by De Laval Ljungstrom (Great Britain) Limited, 129 Kingsway, London, WC2.

Packaged Substation for Refrigeration

Ferranti Limited, of Hollinwood, Lancashire, have entered the packaged substation field with the supply to T. Wall and Sons (Meat and and Handy Foods) Limited of two 1,000 kVA, 6·6 kV/415 volts, Class "C" insulated air-cooled transformers, together with associated medium voltage isolators, and instrumentation and control equipment. The installation is within the factory building and has been introduced in connection with large scale extensions to the cold storage plant of Messrs. Walls.

The transformers are directly coupled through off-load isolators to the bus-bars of a multi-starter contactor switchboard which is made by Morecambe Electrical Equipment Company Limited to control ammonia compressor motors totalling approximately 2,000 bhp. A gallery 9 ft above floor level in the Compressor hall supports the transformers and multi-starter panel.

High voltage switchgear controlling the incoming 6·6 kV feeders to the transformers is located in an existing substation, but can be controlled from the transformers by remote control of solenoid closing mechanisms. Restricted earth fault protection of the transformer medium voltage windings is provided by instantaneous relays, mounted on the transformers, which trip the associated HV switches.

The transformers are totally enclosed and bus-bars are used to connect all cubicles, so that cable faults are eliminated and the whole construction is extremely robust. The chief advantage of self-contained units of this kind is that they can be installed nearer to the load centre of the plant resulting in a major saving in low voltage cabling costs and cable losses. Voltage drop is also reduced; building and maintenance costs are kept to a comparatively low level; and fire protection is unnecessary because no oil is involved.

The rear of the transformer cubicles is removable and the transformer is mounted on rollers to facilitate the removal of core and windings for inspection and maintenance. A cooling air inlet is located at the base of the cubicle and air is ducted from outside the building through a filter.

Between each transformer cubicle and the starter board is an isolator cubicle containing an off-load isolator, control panel and terminal chamber. The isolator has a continuous rating of 1,600 amperes and is chassis mounted in the centre of the cubicle, access to it being by means of a hinged door. All necessary safety devices are built-in.

The complete scheme meets the requirements of the Factories Acts in respect to ammonia explosion hazards, eliminates the necessity for a separate substation, and is claimed to be more economical than any other method of supplying this particular application.

Archdale Preselect Radial Drilling Machine

Here is an engineering product the success of which is due more to sheer technical merit than to any outside factors: for a machine tool is judged by its functionability.

THE Archdale Heavy Duty Preselect machine was designed to make life easier for the operator. The controls are simple and positive and are all grouped together close to the bottom of the drilling head, or " saddle."

When first exhibited in 1948 it represented the first attempt on the part of a British manufacturer to bring greater sophistication into the controls of a radial drilling machine.

The chief innovation in the redesigned saddle for the new machine was the introduction of the preselect gearbox, by which the operator can select the drilling speed for the next operation in advance. Coupled with the preselect feature is an ingenious means for positively locking the gears to prevent them from sliding out of mesh under load, without using heavy springs and balls or plungers, which would have the effect of increasing the effort required for speed changing. Major design problems had to be overcome before this breakaway in radial drilling machine saddle design could be introduced commercially.

James Archdale and Company Limited of Blackpole Works, Worcester, are now one of the 27 members of the Staveley Industries group. They feel a sense of responsibility to every British citizen, for they realize that the price of every consumer durable product sold in the shops or to industry depends upon the processes used in its manufacture and hence upon the machine tools used in its production. Their business has depended upon selling machine tools for over ninety years, and their customers expect them to keep their well-established range of products up to date. The heavy duty preselect drilling machine has taken its place as a logical stage in the history of radial drilling machines.

James Archdale was a Yorkshireman who, after securing valuable engineering experience with several well known firms, set up his own machine tool business in Birmingham in 1868 at the early age of 29. Although lathes were prominent among his products, he made no attempt to specialize in particular kinds of machine, and would tackle any machining problem as it came along. All his products reflected his " quality first " attitude, for which the company are still renowned today.

The business was soon established at Ledsam Street Works, Birmingham, where expansion continued and finally reached a limit about 1910. Nearly every tool on the premises was of the firm's own manufacture, a striking indication of James Archdale's policy of " no specialization."

However, conditions during the First World War brought a change to this policy, and

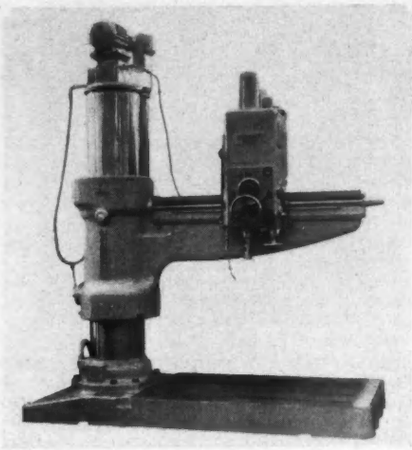


Fig. 1 The Heavy Duty Preselect machine.

thereafter the company concentrated upon drilling machines (vertical, radial and multi-spindle), milling machines and special-purpose drilling and boring machines.

The story of development of the company's radial drilling machines would not be complete without mention of Mr. W. F. Clark, who was appointed works manager in 1889 and later became a director. It was he who conceived the idea of drilling machines with centralized controls, since from the early days the controls were scattered all over the machine involving the operator in much unnecessary fatigue and loss of time. The centralized control conception was to group all the controls on the drill saddle, an arrangement which materialized finally in the high speed machines introduced about 1935, as shown in Fig. 2. The preselect machine, in which the controls are still further grouped and localized around the lower portion of the saddle, is a logical descendant.

The depression following the First World War found James Archdale gradually changing over from belt driven to built-in motor driven machines. In 1925 the proportion was roughly 50-50, and in the previous year the company had produced the first multi-stage special purpose transfer machine in the world—the birth of automation. About 1921 a branch factory was opened at Blackpole, Worcester. Since then Archdale have enjoyed a healthy, steady expansion, coupled with a gradual transfer of their entire factory and office premises to Worcester. Today the move is complete.

The effect of the Second World War was to further rationalize the company's products and impose a halt on the progressive redesign of the standard range. With the cessation of hostilities the management were quick to review the standard range, with an eye on the increasing competition the future was to bring, both from the UK and overseas. All the standard machines dated back to the 1930's or earlier, and one of the decisions taken at that time was to give the design department the job of redesigning and restyling the currently popular medium duty high speed radial drilling machines.

The designers aimed firstly at simplifying the controls, and making them more " handlable " and accessible to the operator by grouping them low down on the drilling saddle. Secondly, they aimed at restyling, to improve the appearance of the saddle and make it more convenient for manufacture, painting and keeping clean. In the preselect machine only two speed change controls are needed, the selector dial and the change lever, in place of three on its predecessors.

1946 saw completion of the prototype which offered 12 drilling speeds. When the production machines were introduced two years later the number of speeds had been increased to 16, still with 2 controls—which would have meant four change levers if the previous type of saddle had been employed.

The speed change device is the heart of the heavy duty preselect saddle, and was designed to meet two main requirements:

(1) Speed change controls to be few in number and all within easy reach of the operator over a wide range of arm positions.

(2) Gears to be positively located to prevent them from coming out of mesh under load.

PRESELECT SPEED CHANGE

Preselection of the desired speed can be done at any time with the spindle either revolving or stationary by turning the selector dial on the left hand side of the saddle. The actual speed change is made after stopping the spindle, by pulling the long vertical lever on the same side of the saddle forward through an arc of about 30°, and then returning it. Operation is equally convenient whether the arm is in its highest or lowest position.

The 16 speeds are obtained by using four sliding gear clusters carried on vertical shafts. Each cluster is controlled by its own clutch and has two possible gear positions obtainable by rotating a crankshaft through 180°. The positive gear locking feature depends upon this crankshaft, for the final position of the gears is with the crank at top or bottom dead centre.

Figs. 5 and 6 represent diagrammatically the preselect mechanism for a typical gear cluster before and after speed changing. In Fig. 5 a new speed has been selected and the selector cam has been rotated, thus raising the right hand latch lever out of engagement with the controlling member. In Fig. 6 the controlling member is restrained between one of the latch levers and a fixed abutment, which is the normal running condition when the alternative speed in that particular cluster has been selected.

The operating clutches, one for each sliding gear cluster, are mounted on a common shaft. When the controlling member is restrained from rotating, the corresponding clutch is " free " and moving the change speed lever will have no

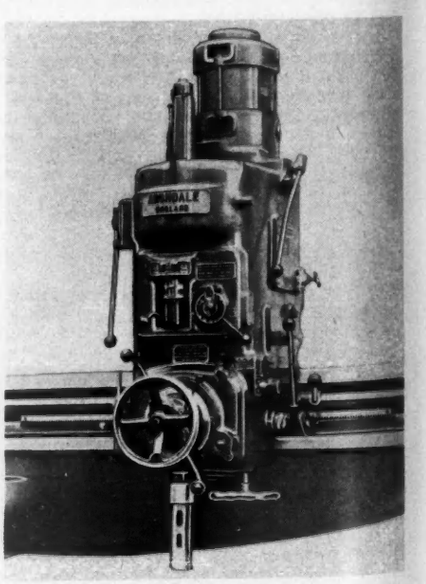


Fig. 2 The High Speed Medium Duty machine —the preselect machine's predecessor.

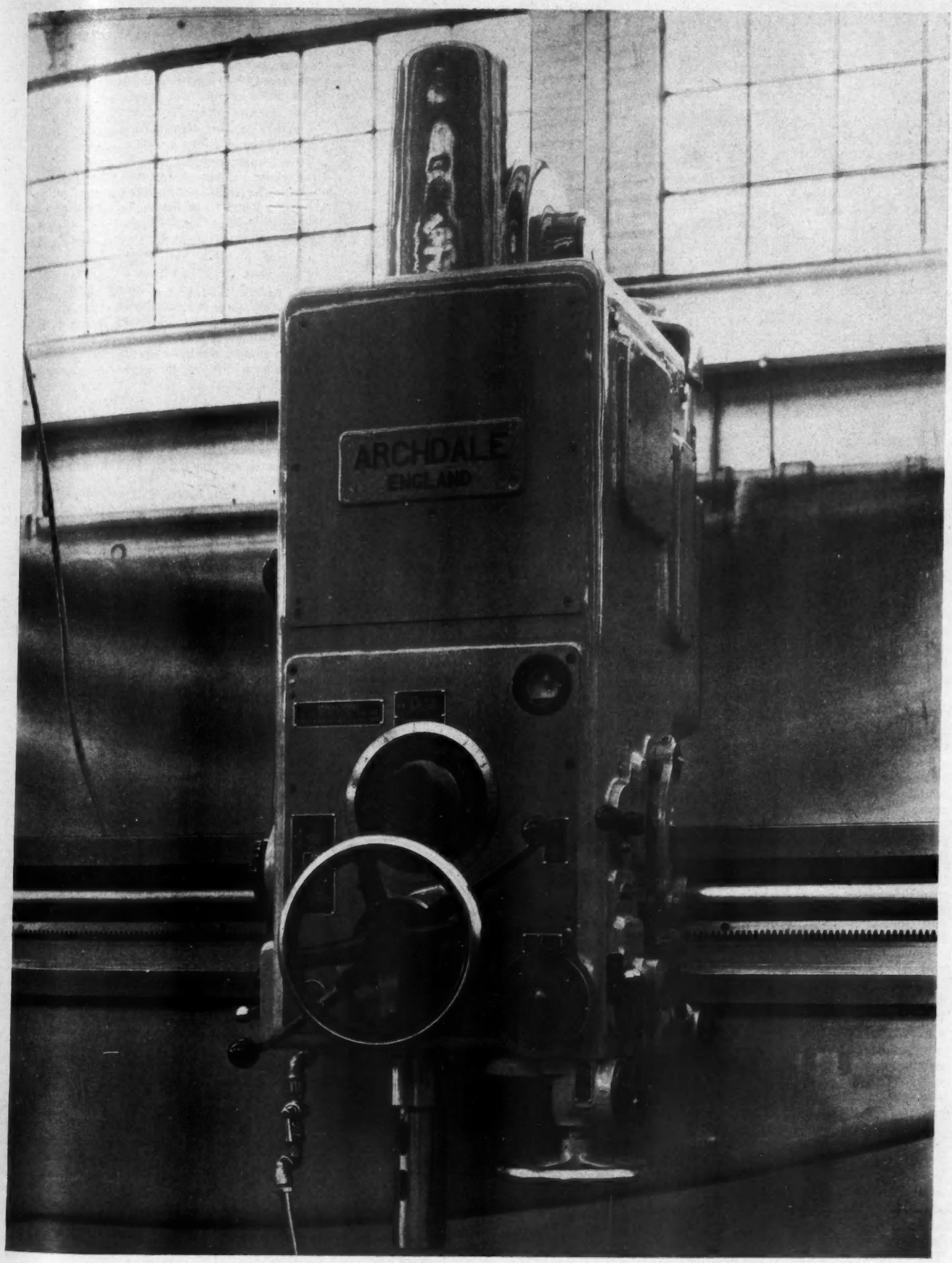


Fig. 3 A significant stage in a story of steady progress.

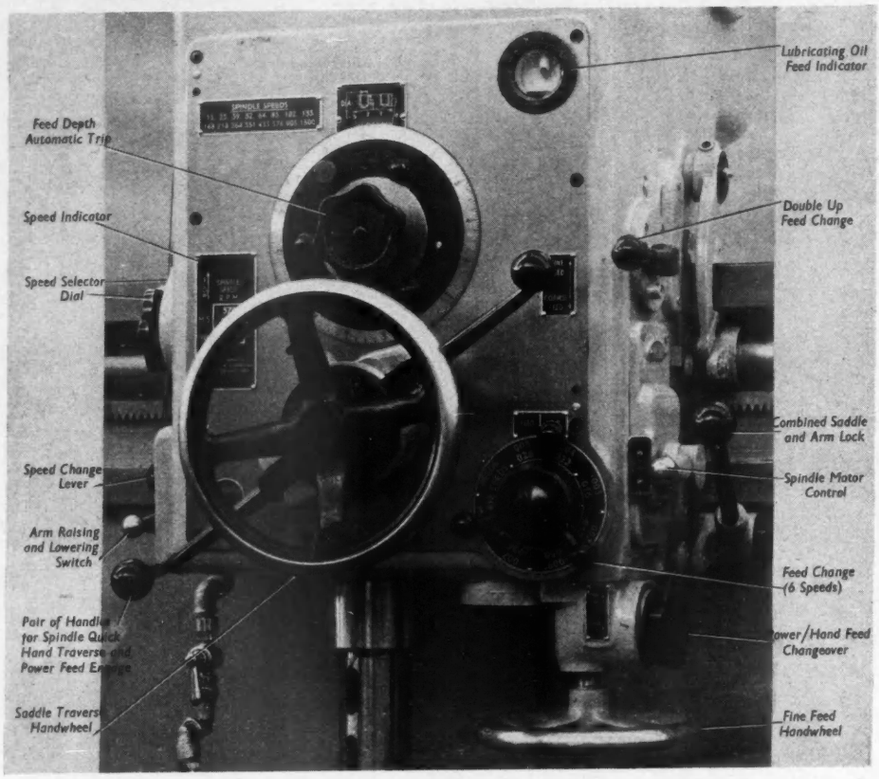

Lubricating Oil Feed Indicator
Feed Depth Automatic Trip
Speed Indicator
Double Up Feed Change
Speed Selector Dial
Combined Saddle and Arm Lock
Speed Change Lever
Spindle Motor Control
Arm Raising and Lowering Switch
Feed Change (6 Speeds)
Pair of Handles for Spindle Quick Hand Traverse and Power Feed Engage
Power/Hand Feed Changeover
Saddle Traverse Handwheel
Fine Feed Handwheel

Fig. 4 Conveniently grouped layout of controls.

effect on that particular gear. However, with the controlling member unrestrained and free to rotate, as in Fig. 5, the operating clutch engages the segmental gear with the speed change lever, and when the lever is moved the gear drives the crankshaft and thus moves the sliding gear cluster. The 30° angular travel of the change speed lever corresponds with 180° rotation of the segmental gear and the crankshaft.

Considering the system of four gear clusters as a whole, turning the selector dial to the required speed position has the effect of lifting the appropriate latch levers clear of the corresponding controlling members, while allowing the others to remain in engagement. Thus, when the speeds are changed, the gears which are already in the correct position for the new speed are not moved as the corresponding clutches are "free." The other clutches will be rotated through 180° and the controlling members automatically latched in the new position, ready for restarting.

An overall speed range of 100 to 1 is provided, and the number of speeds offers mechanical convenience in design coupled with a useful working choice, without too big a step ratio between speeds in the most frequently used part of the range. The sixteen speeds are obtained from a simple $2 \times 2 \times 2 \times 2$ arrangement so that each sliding gear has two positions only. This arrangement enables the driving gears to be placed close to the shaft bearings, and short rigid shafts can be employed.

The normal speeds in rpm are: 15, 25, 39, 51, 64, 81, 104, 130, 172, 215, 270, 350, 445, 560, 900 and 1500. The twelve speeds 39 to 560 have a closer step ratio than the remainder, and they provide a useful range of speeds for normal drilling operations.

Rate of feed on a drilling machine is often regarded as being more critical than cutting speed. Ideally the feed should be infinitely variable to suit the job, and be subservient to the other variable factors. In the simplest form of drilling machine the feed is under the continuous control of the operator. In a modern high speed radial machine the feed is automatic and a choice of feed rates is provided, to be selected and engaged by the operator. Twelve feed rates are provided in the preselect machine varying between 0·002 and 0·050 in per drill revolution. Originally only six rates were offered, but these were later doubled. Power feed is engaged by pulling forward the cross-handles which also operate the spindle quick traverse, situated at the front of the saddle, as shown in Fig. 4. A fine feed handwheel is fitted for spot facing operations.

Other controls on the saddle of the preselect machine include the spindle motor control, saddle traverse handwheel, arm raising and lowering switch, feed depth automatic trip, power/hand feed changeover, and combined saddle and arm lock. Many detail design problems had to be overcome in order to obviate physical interference. A speed indicator gives recommended drill speed and feed rate.

The spindle motor is usually installed in the saddle as a built-in stator and rotor assembly, though a separate motor can sometimes be substituted to customer requirement. A comprehensive safety system is provided to safeguard the machine against careless handling, for example overtravelling of the saddle, arm or spindle, or overloading the feed drive.

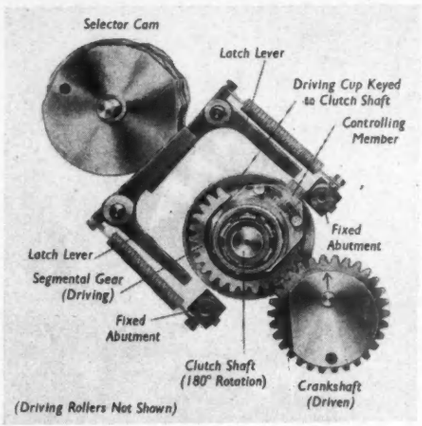
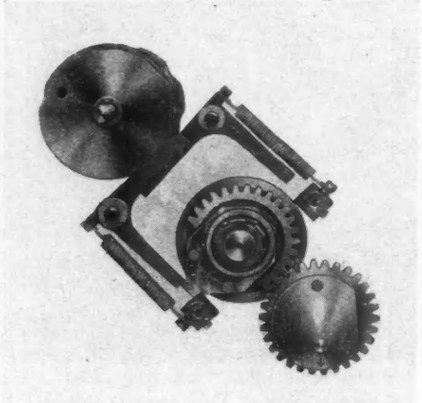


Fig. 5 (above) The preselect mechanism prior to speed changing.

Fig. 6 (below) After speed changing. The crankshaft has been rotated 180°.



DRILLING CAPACITY

The drilling capacity of the heavy duty preselect machine is 3½ in in mild steel. For the customer who insists on having a lighter type of machine to the latest design, Archdale introduced a new medium duty preselect machine in 1956 with a drilling capacity of 3 in, but the heavy duty machine is the more popular.

The preselect machine is technically ahead of comparable machines any other British firm can offer. In machine tools, as with other engineering products, a single new feature would not be sufficiently popular on its own to justify the inevitable slight price increase. It is the number of additional refinements that are brought in at the same time which finally determine its success. In the preselect heavy duty machine the customer gets increased drilling capacity, slicker operation and improved styling for his money in addition to the preselect feature. Archdale were therefore confident that the new machine would earn itself a place as a "bread-and-butter" line and it has.

Today, as in earlier times, special purpose machines play a large part in the firm's activities, and when ENGINEERING's representative visited Worcester he was shown some impressive multi-purpose transfer machines in course of erection. These machines are intended for drilling, milling, tapping and boring operations on components required in large quantities, particularly for the motor vehicle industry.

While Alfred Herbert Limited with their world-wide coverage act as sole selling agents, service facilities are provided direct from Worcester and the company are particularly proud of the speed with which their staff reach a customer in times of trouble. Their good reputation is further enhanced by a scheme of "goodwill calls" wherein every customer is visited at frequent intervals even though he may never request a call for service. Despite the increasing competition among machine tool makers, the company's steady expansion continues. The only drawback to Worcester is that in a city with a population of less than 65,000, labour competition is keener than in a large industrial centre. However, labour relations are good, business is brisk and Worcester itself is gradually becoming more highly industrialized.

British Industry in Moscow

Marketing

THE largest foreign trade fair yet held in Moscow, with 621 British companies exhibiting, opens in the Sokolniki Park today (19 May).

Sponsored by the Association of British Chambers of Commerce and by the All-Union Chamber of Commerce of the USSR, the Trade Fair, which runs until 4 June, has naturally turned out to be an extremely broad presentation of British manufacture, from the heavy power equipment and scientific instruments of ASSOCIATED ELECTRICAL INDUSTRIES through the cars, trucks and locomotives of the transport sections to clothing, textiles and the shoes of FREEMAN, HARDY AND WILLIS.

With the comprehensiveness of the show established, the first and most important question expected from the Russian visitors, whether private citizens or high level representatives of the impressively named Soviet import-export organizations, is whether they are being shown the latest developments.

A Century of Trading with Russia

An important witness on this point is Mr. W. L. Mather, chairman of MATHER AND PLATT, whose history of trade with Russia extends to more than a century ago, their first order being booked in 1858. Mr. Mather has attended earlier national shows in Moscow and carried out business trips of his own. He is in no doubt that the most important element is that the exhibits being shown must be the most up to date. Mather and Platt have themselves put this into practice, spending £30,000 and seeing to it that a model of their exhibits was photographed and then not only criticized by their own executives but also by representatives of the All-Union Chamber of Commerce of the USSR.

Along with hundreds of other companies, Mather have been giving their directors and certain technicians and salesmen a series of one-hour Russian lessons, although the company has the advantage of already having Russian-speaking engineers on its staff.

For the Soviet visitors, their imaginations fired by engineering and scientific achievements now symbolized by Major Gagarin's spaceflight, the Board of Trade exhibit should strike the right introductory note. It spreads over 10,000 sq. ft the story of what Britain is doing and has done in science and engineering. Stress is laid on the way in which industry, the universities and Government bodies cooperate in contemporary research.

The Board of Trade stand covers the nuclear power programme and radio-isotope production, hovercraft and civil aircraft developments, particularly in navigational control systems and vertical take-off. Terylene and polyethylene appear as the stars of the graphically related story of artificial fibres.

The USSR Poplov medal was awarded to Dr. Essen of the National Physical Laboratory, at Teddington, for his work on the "Atomic Clock" and the principles and practical applications of the clock are one of the display subjects of the stand. Highly sophisticated light and sound effects are employed as background to the presentation of Professor Sir Bernard Lovell's work at Jodrell Bank and of Professor Martin Ryle's work at Cambridge.

The famous Melrose heart/lung machine which has already been seen and bought in the Soviet Union forms part of the advanced medical research feature.

Marconi Instruments for Telecommunications

No less precise than the instruments of medical research are the electronic measuring instruments for telecommunications, taken as their theme by MARCONI INSTRUMENTS Limited, of St. Albans, Hertfordshire. There are more than a hundred standard telecommunication measurement equipments in the company's range and the most interesting of them are on show as part of the ENGLISH ELECTRIC Group display.

One of the Marconi exhibits is the Suppressed-Zero Voltmaster (TF1377) which is a potentiometric slideback voltmeter for measuring absolute voltages up to 500V and changes as low as 1 mV in the source under test. The precision incremental measurement system of the TF1377 is particularly suitable for a variety of applications, including regulation and stability tests on dc voltage sources, temperature coefficient measurements on semiconductors, resistors and so on, direct strain-gauge tests, calibration of resistance thermometers and piezoelectric transducers and the regulation of generators.

The FM Signal Generator (TF1066B) covering the frequency range 10 to 470 Mc/s acts as a precision fm generator in the testing and aligning of vhf and uhf receivers both for broadcast and communications systems, whether fixed or mobile. With oscilloscopes of advanced form and bridges, including the low capacitance TF1342, the Marconi Instruments company presents a range of instruments to the Soviet industrial visitor that meet the Russian emphasis on highly developed forms of control at a great many points.

Expanding Market in Household Appliances

Exporting all over the world, the TELCON METALS Company, now part of the BRITISH INSULATED CALLENDER'S CABLES Limited group, has both the sales experience to ease their contacts with the Soviet trading bodies and the specialized metals on their stand in Hall B to provide the answer to problems common to manufacture whether in the USSR or Great Britain.

The range of high permeability alloys and nickel-iron compositions produced at the Telcon works at Crawley, Sussex, is widely used in electrical instruments, current transformers, telecommunication transformers, recording heads, amplifier components, relays, small motors, magnetic amplifiers and light-weight generators.

As well as examples of such applications Telcon are showing thermostatic bimetals and a number of glass-to-metal sealing alloys. As Soviet housewives increasingly enjoy the benefit of the washing machine and other household appliances the market for bimetals will grow particularly swiftly.

Copper Rollers from St. Helens

Equally connected to the demand for powered appliances are the nickel iron and silicon iron laminations being shown by MAGNETIC AND ELECTRICAL ALLOYS Limited. These are used in small transformers and chokes and preassembled rotors and stators for the motors of domestic appliances. Cold rolled silicon iron cores for transformers and chokes are being displayed by TELCON-MAGNETIC CORES Limited. With Magnetic and Electrical, Telcon-Magnetic is a Telcon subsidiary.

A relative newcomer to the BICC group, THOMAS BOLTON AND SONS, who set up as long ago as 1783, are deployed over a third of the Telcon stand. High conductivity copper, which finds its principal application in electrical engineering, is being shown by Thomas Bolton in strip and wire, sections, plain and shaped commutator bars and segments, bars and rods, bus-bars, contact wire, rotor and stator end-rings, hollow copper conductors, and in specialized form for many electronic devices.

An elegant section of the Thomas Bolton stand shows six copper printing rollers, each revolving about its axis, on a turntable backed by the printed fabrics and plastics for which the rollers are used. From their St. Helens, Lancashire, works, Thomas Bolton produce copper printing rollers for printing dress materials, calico, plastics, handkerchiefs, wallpaper and floor coverings among other products. Some among the visitors should be familiar with the company's BS copper ingots, which have an existing market in the Soviet Union. In a country proud of its book and periodical standards, the display of zinc and copper sheets for printing, engraving and lithographic offset is certain of enthusiastic attention and some questions in fine detail to the men on the stand. In line with the general practice of the show the first line of explanation has been provided in Russian and English captions to the exhibits and illustrations.

A Lecture from the Chief Colourist

Another of the exhibitors whose name is familiar in Soviet industry, IMPERIAL CHEMICAL INDUSTRIES have spread themselves lavishly on a two-deck stand, designed by Mario Armengol and built by CD PRODUCTIONS Limited. Dyestuffs, Plastics and the Fibres divisions have the three largest displays, occupying almost half the stand, but no division of ICI goes unrepresented.

Procion and Procinyl dyes discovered by ICI chemists are the highlights of the dyestuffs display. This is a division whose trade with the Soviet Union has been growing over the years. Procion and Procinyl are the first reactive dyes in the world and they are already being used in Soviet manufacturing. They are increasingly employed in textile dyeing and printing. Supplementing the visual demonstration of the display, Dr. T. Vickerstaff, chief colourist of the division, whose book *The Physical Chemistry of Dyeing* has been published by the Moscow Technological Institute, is lecturing on "How Reactive Dyes Work."

Spanning the industrial and the consumer interest of the Trade Fair, the Fibres division is showing industrial uses of Terylene polyester fibre and there will be a Terylene fashion show in the course of the exhibition.

This is not the first time round for the Plastics Division who, last year, put on a successful exhibition of their own in Leningrad and Moscow. For them the Moscow show serves the double purpose of making new contacts and consolidating those established at the earlier exhibitions and in the growing trade between the division and the Soviet trading bodies. Fabricated in London for speed of assembly in Moscow, the floor of the ICI stand is made from the company's pvc tiles.

Some idea of the pace of growth in ICI's marketing activities in the Soviet Union is given by the Heavy Organic Chemicals division, the most recently formed of the divisions. A substantial export trade in petroleum chemicals has been developed to Russia and there have been bulk shipments of tonnage organic chemicals by tankers sailing direct from the ICI works on the River Tees to the Baltic ports.

No Russian caller at the ICI stand is likely to go away without at least the opportunity to take along literature giving him detailed information of ICI products and activities. More than 50 tons of ICI literature has been printed in Russian for the fair, much of it technical but with two general brochures on the group.

Sir Reginald Rootes and Operation PYTC

Any attempt to give details of the legion of industrial leaders in Moscow for the fair, or part of it, would fail for lack of space, but one of the most active is Sir Reginald Rootes, chairman of the ROOTES Group manufacturing division and deputy chairman of Rootes Motors Limited. With Mr. Derek Curling, a director of Rootes Export Division, Sir Reginald is leading a vigorous sales team from Rootes, who have assembled the largest display of cars and commercial vehicles in the show.

For Rootes the Moscow exhibition—Operation PYTC, the Russian spelling of Rootes—is part of a broad Eastern European sales drive. The group has exhibited at the Leipzig Trade Fair and is to show at Budapest, Hungary; Brno, Czechoslovakia; Poznan, Poland; and Belgrade, Yugoslavia.

Over the past 18 months a thousand Hillmans, with quantities of replacement parts, have been shipped to Czechoslovakia and Commer trucks and Humber and Hillman cars have been supplied to China.

In this there is a hint of the wider significance of the British Trade Fair in Moscow. The opportunities to be seized in trade with the USSR are potentially immense. There is also the chance, due to the influential position occupied by the Soviet capital, of making a considerable impression on the industrial and consumer buyers of the Eastern European states, and to some extent of China.

On the Shelf

By Frank H. Smith

AT AN Aslib meeting held at the Royal Aeronautical Society, Sir Frank Francis, director of the British Museum, and Professor R. S. Hutton opened a discussion on the new National Reference Library of Science and Invention projected for the South Bank, and its relations with the new plans for the British Museum Library. Professor Hutton (who contributes an article on the subject in this issue of ENGINEERING) spoke first and reiterated some of the criticisms he had already made, in the *Journal of Documentation*, of the Patent Office Library. Sir Frank's contribution was an outline of the plans visualized.

When the discussion was thrown open to the meeting there was no lack of speakers. The chief question seems to have been that of the traffic arrangements between the British Museum at Bloomsbury and the proposed Library on the South Bank—a distance of about a mile as the crow flies, but slap across the centre of London. The time factor was, of course, the bone of contention and suggestions came freely, ranging from closed-circuit television to the using of the old Kingsway tram tunnel. This last came from a representative of the Bristol Aircraft Company who did not, surprisingly, suggest a helicopter.

A distressing fact that came out of the discussion was that the scheme does not allow for *unlimited* expansion. The South Bank building has not even been started, yet there is talk of the limitations imposed by the LCC regulations and others. With the new Shell building and the Vickers headquarters as near neighbours, it is difficult to understand why the new national reference library should not be as high as the Tower of Babel, which it will so nearly resemble. Whether the discussion will influence the planners remains to be seen but it is certain that, with its specialized membership, Aslib can make valuable contributions to the success of this project—if its suggestions are considered.

The National Academy of Sciences (2101 Constitution Avenue, Washington 25) announce a new monthly abstracts journal, *Environmental Effects on Materials and Equipment*, to consist, monthly, of at least 40 substantive (substantial?) abstracts plus 40 or more " extracts " (telegraphic or key-word abstracts). These are what *we* sometimes call informative and indicative abstracts I think. $25 a year and it is largely connected with the space race.

My first from Thailand is *Journal of the National Research Council of Thailand*, with editorial names like Kalakicha, Yanasugondha and Punnahitanond. Most of it is in English, the address is National Research Council, Rama VI Road, Bangkok, Thailand, and the subscription is 100 baht a year, which is the same as £1 16*s*. The subject matter is natural and social science and No. 1 was Nov., 1960.

" Relatively new " is how the Central News Limited (Pemberton House, East Harding Street, London, EC4) describe *Business Automation*, which they produce " triannually "(cor!) on behalf of Block and Anderson, the people who do the BANDA and other office machines. Very fetching it is, too.

My congratulations to Blackwell's, of Oxford, on their folder *When You Visit Blackwell's*. If you want to know why, write and ask for one.

It will be remembered (a figure of speech) that a year or so ago I called attention (in the interests of leisure and my desire to cater for all) to a book *Be Your Own Gardening Expert*—an unusually presented and inexpensive publication. Now the same people, Pan Britannica Industries Limited, Waltham Abbey, Essex, and the same author, Dr. D. G. Hessayon, have produced *Be Your Own Lawn Expert* at 1*s* 6*d*. The same technique of presentation has been used and coloured illustrations help you to eradicate the unwanted Old Man's Boot and so forth and to retain the grass pure.

Aircraft Production in France

Fabrication des Avions et Missiles. By M. P. GUIBERT. 2nd edition. *Dunod, 92 Rue Bonaparte, Paris, 6.* (125 *NFr*)

The aircraft industry is one which makes the most spectacular technical progress. This progress is evident from the manufacturing methods employed and the continuous perfection of new processes. In this book the author gives an account of planning procedures, their purpose and the methods involved.

After treating general questions of tooling development, M. Guibert considers the production of components, e.g. by profile milling, boring, shaping, classical forming, forming by shot peen and by explosion, forging, extruding, casting, and such special processes as electrochemical milling, milling by high-frequency vibration and chemical milling.

The author goes on to review heat and surface treatment, and methods and principles of assembly and fabrication, including welding by high-frequency vibration, by electronic bombardment, by plasma torch, by brazing and by hot and cold bonding for honeycomb. Next he discusses continuous assembly, assembly tooling, laying out, final assembly, and factors affecting precision and interchangeability, such as deformations and tolerances allowed for assembling components manufactured in different parts of a country having other climatic conditions.

Special manufacturing processes for aeroplanes built of wood are then examined, together with revisions, repairs and modifications. Cases of limited production provide the subject of a further section, for example the manufacture of prototypes and early types, a long production run of an early developed type and the construction of later types developed from a main type.

There follows an important chapter in which the author analyses the factors and principal aspects of aeronautical manufacturing evolution due to the advent of new materials (such as high strength light alloys, titanium, plastics and composite materials), new toolings, new processes, new machines, new aircraft (subsonic, supersonic, hypersonic aircraft), and heating problems met in particular in ballistic missiles. The production of missiles is treated in the last chapter of the book.

This 847 page book, which arises from a lecture course by the author at the Ecole National Supérieure de l'Aéronautique, is not only of interest to those employed in the aircraft industry but should be useful to all those who have to organize, to realize, to follow, to control any manufacturing process.

The various subjects treated—the developments of ultra-modern manufacturing processes —the graphs, drawings, schemes, photographs, totalling 693, and documents, make this an outstanding book for planning and tooling engineers. It should also be of great use to student engineers, designers, project engineers, technical and control staff and all those whose careers are in production, especially those in the aircraft and missile industries. It is of the greatest importance for engineers generally to be familiar with the various manufacturing techniques, their possibilities, their limitations and costs.

Unless the reader takes for granted the algebraic expressions in the first chapter on planning procedures, it might have been better, in order to help in understanding how some of them were derived, if the author had numbered them for a later reference. This would save the time which the reader is likely to spend in finding the required substituted relationship. But since the expressions are not too numerous, this fault is not serious. The above-mentioned expressions must be used with some caution as planning procedures in the British aircraft industry may differ from those in their French counterpart.

It is a pity that the material specifications mentioned in the book are French, but if a conversion table is used this difficulty may be easily overcome. Material specification tables may be obtained from Agard's *Material Properties Handbook* (volume 1 for aluminium alloys, volume 2 for steels), the Technical Department, the Royal Aeronautical Society, 4 Hamilton Place, London W1.

This review treats only part of the book's contents but, in its comprehensive coverage, it would be invaluable in the library of any aircraft firm.

G. R. J. E. LEGUEN DE LACROIX

Economy of Effort in Learning Russian

Translation from Russian for Scientists. By C. R. BUXTON and H. SHELDON JACKSON. *Blackie.* (30*s*)

It is no joke for an engineer or scientist, long accustomed to eschew inconsistencies and to forget irrelevancies, to condition his tired brain to the assimilation of strings of irregular verbs and other horrors involved in learning a new language. The whole thing amounts to a prodigious exercise in memorizing arbitrary rules and unrelated facts. One can well imagine that languages might come more readily to historians, for instance, or perhaps lawyers, because their training embodies a substantial ingredient of unrelated-fact-memorizing.

This aspect of language learning is so important that it may not be out of place to ask an engineer or scientist about to embark on learning Russian to glance through one of the popular books which describe the memory, how it works and the best way to memorize nonsense ryhmes and jumbles of words. For instance, I. M. L. Hunter in *Memory, Facts and Fallacies* (Pelican Series) describes the logarithmic relation between the amount retained in the memory after learning and the time elapsed between successive re-learning periods. He gives some valuable rules about memorizing, thus " Distribute practice, making memory drills short and stopping at the first sign of fatigue."

Various textbooks have been published purporting to aid scientists to acquire a working knowledge of Russian, but, to the writer's knowledge, they are not written with this memory slant as the dominating theme. Unfortunately *Translation from Russian for Scientists*, by C. R. Buxton and H. S. Jackson, is hardly an exception to the general run of Russian textbooks in this matter.

Russian students, of various stages of proficiency in the language, are unanimous in asserting that there is no easy way, no short cut to learning the language, or even just understanding written text. The opinion is that it is absolutely essential to master some grammar at the outset, otherwise it is not possible to pick out the parts of a sentence, in other words to identify verb, nouns and other elements.

Both this book and several other textbooks (for instance *Russian for Scientists*, Turkevich. Van Nostrand) begin by familiarizing the student with " cognates," words which are phonetically identical in Russian and English such as various scientific terms, geographical place names. This is excellent, for it is a useful way of assimilating the Russian alphabet, which of course has to be mastered at the outset (according to one student it can be learned in two hours). With the ability to read and recognize cognates in Russian scientific texts, the student has reached a very useful and important stage, because so much of the literature in this sphere is loaded with recognizable words, and it is possible to see what the whole thing is about.

Buxton and Jackson's book contains a comprehensive grammar section which extends to page 89. An interesting feature of this section is the emphasis which is placed on words in Russian which appear to be derived from, or are of common derivation with, German, French and Latin words as other representatives of the Indo-Germanic language family. (The authors even indicate equivalent words in Welsh, but this similarity is hardly relevant as they are not of Celtic origin but were taken from the Roman invaders of Britain). This approach has merit in that it may ease the engineer's or scientist's task of memorizing, for it presents him with some sort of foothold, some glimmer of relevance in at least some of the many words to be learnt.

The second section of the book contains lists of Russian sentences which have to be studied in connection with the grammar of the preceeding section. The student is left, however, with very little guidance indeed as to how much, or what grammar to learn. This lacuna is very disconcerting, because it is impossible to learn all the grammar, before trying it out in sentences. Fourman's *Science Russian Course*, a smaller volume, only gives a basic or simplified grammar, and this approach seems to the writer to be more logical at this stage, at least.

The student's task is made all the more difficult because there is no key or translated rendering of these sentences to which he can refer, if only to check his own attempts, if not to correct them.

It seems to the writer that the human mind is not unlike a mechanical computer in its functioning, in that it has to throw up fresh images continually, to concoct them so to speak out of its own resources, and then to match them against reality. In language learning, a student must constantly make his own attempts at synthesising sentences, matching his versions against correct " key " versions until the difference between them, so to speak, reduces to zero. This " participation " in learning is important.

The third section comprises first of all, annotated texts, namely, sections of Russian scientific texts in which the subjects of the sentences are underlined, and some of the words are explained in footnotes immediately underneath. This method is valuable, the only criticism being that this kind of thing has not been carried far enough. The first extracts of the texts could have been analysed in far greater detail, every word being explained so that the student is left in no doubt whatsoever about the text by the time he has got through it. Several pages could be devoted, for instance, to the first extract, which is only about 14 lines in all. Each succeeding text need, of course, carry less explanation.

But by the time we reach extract 7 in the book, we find we are dealing with a lengthy article on earth satellites with what appear to be rather sketchy notes and references to perfective and imperfective tenses. Incidentally, an attempt is made in the grammar portion to explain this difficult subject, and it is hardly doing the authors an injustice to say that the student is probably in for a very sticky time.

The reader is expected to refer back frequently to the grammar section and forward to the vocabulary. In a book of this nature there should be a thumb index of sorts, as in the case of various handbooks and manuals. This criticism applies to all the Russian textbooks seen by the writer, so far. The conventional book, after all, has been evolved with the express idea of going from page 1 to the last page progressively, a chronological series of presentation as in the case of a film or play. There is no point in adhering to this conventional design when the book is not necessarily intended to be used in the conventional way.

With regard to the last main section of the book, we have 156 separate Russian texts culled from various technical journals, divided under general subject headings. But there is no key or translated version of these texts, so that it is difficult to see any real advantage in including them as compared with the readers consulting the actual current technical journals of immediate interest to him. Surely, if he is already at a sufficient state of proficiency to be able to tackle such exercises, why should he not be putting his valuable acquired knowledge to use? If this section were eliminated, and the more explanatory second and third sections developed in greater detail, the book might be more valuable, at the same cost.

In conclusion it is fair to repeat that the learning of a complex language from a book without the assistance of a teacher is a problem which makes very great demands from the book and its authors. The reader must be gently led by the hand, and if the book is to be in the conventional form, that is intended to be read from page 1 onwards in proper sequence, it must be related to the human mind and its peculiarities of memorising and forgetting. Many points will have to be repeated on successive pages, and referring back cut down to a minimum. The student should also be continually made to " participate ", in other words, to make his own translations and to check them against carefully detailed keys and translated versions.

V. H. BRIX

Promoting National Evolution

Industrial Development: A Guide for Accelerating Economic Growth. By MURRAY D. BRYCE. *McGraw-Hill, New York and London.* (58*s*)

Mr. Bryce, a Canadian economist and industrial research consultant, offers a practical, simply written, do-it-yourself textbook for business men and government officials, who are called upon to prepare industrial projects in developing countries, but who lack the experience of how to set about collecting and analysing the necessary facts, how to assesss the feasibility and potential returns of a project, whether big or small, and how to find the finance for it. His book should also be invaluable to any British exporters who may not have previous experience in dealing with projects in underdeveloped countries.

The chapters cover such practical problems as the technical, economic, and financial investigation of a project, the analysis of its domestic and foreign market prospects, its comparative costs and risks from competition, analysis of capital-cost estimates, measuring working capital requirements, estimating sales revenues, operating costs, and estimating the cash flow. He also discusses the preparation of designs and specifications, tenders and contracts, the work of engineering consultants, and the essentials of good management. In another section he considers the employment of foreign experts; how to seek local finance, and whether by loan or equity; the advantage of foreign participation, and how to attract foreign loans or equity capital, particularly from the World Bank, the International Finance Corporation, the United States Export-Import Bank, the Development Loan Fund and other American sources.

There is a major gap here in that Mr. Bryce makes no mention of the City of London, and appears unaware that London bankers and finance houses have more specialist experience in overseas investment than any other centre in the world.

That the world is suffering from a shortage of development capital is, of course, a truism, but Mr. Bryce believes that providing a project has been realistically prepared, it has good chances of finding backers. Mr. Bryce's point is a variation on the proposition that most professions are overcrowded with second-rate practitioners at the bottom, but that there is always a scarcity of outstanding men at the top. It emerges from Mr. Bryce's pages that the overwhelming majority of local projects fail to secure foreign finance because they are ill-conceived, or rendered unattractive by conditions inspired by nationalistic feelings rather than purely economic requirements. It therefore seems arguable, paradoxically, that a real world shortage of capital will only emerge when, and if, all projects are prepared in accordance with Mr. Bryce's strictly economic principles.

That Mr. Bryce is wholly sympathetic to the developing countries should dispose them to heed his warning of the errors made by so many. The question that Asian planners should ask is " how can the national income be most increased for the least cost? " Instead, they usually assume that wealth comes from industrialization itself, so they create uneconomic industries and bolster them by tariff protection. They think that national safety requires self-sufficiency, so they build up defence and automobile industries which are expensive to run because their output is limited by a small market. They consider that handicrafts are socially valuable, so they preserve them by subsidies. In order to protect their balance of payments, they invest in national shipping companies or in synthetic petrol plants at uneconomic rates. Political pressures often prevent them from locating industries on the most economical sites and induce them to spread schemes evenly over the country, with special attention to backward areas.

As Mr. Maurice Zinken says in his *Development for Free Asia* (Chatto and Windus), " The list of errors into which the ignoring of profits leads is long. Separately, they can be justified by some non-economic consideration, from defence to human charity. Together they are keeping the people of Asia in poverty and squalor and ignorance for longer than is necessary."

Another important warning that Mr. Bryce utters is that unless a developing country has some unusual resource, such as oil, it would do better to build what it wants—industry—on the strength of what it already has—agriculture. Historically, agriculture has been the one big paying activity from which industrialization has been financed, and has also been the one large consuming section of the community which could provide a market for new industrial goods. Agricultural development has not the spectacular glamour of a new steel works, but it may be the sounder priority. The greatest improvement in the well-being of many countries would come from raising agricultural productivity. This priority does not mean that there is a conflict between agriculture and industry, but that their development is intermeshed. Unless agriculture modernizes itself, industrial expansion is usually cut short by lack of markets because the masses have not the money to buy industrial products.

Some argue that the base for all development is heavy industry and that it must be created first, even at sacrifice. For the world as a whole it is true that heavy industry is essential to support other industries, but for an individual country, this is not necessarily so, and for many small developing countries, it is misleading. Generally, it is cheaper for them to import heavy products from industrialized countries that can make them economically for a world market. Occasionally a developing country can successfully build heavy industry when, as in India, it has natural advantages in raw materials, such as good iron ore and coal for steel, but in that case it will be successful not because the project is heavy industry, but because it is sound in itself.

Mr. Bryce offers some sensible comments on tariffs to nurse infant industries. He concedes

that where an industry is economically sound for a country, in other words, when in normal operation it can produce at costs fully competitive with other countries, it is right to grant *moderate* protection to enable it to establish itself. But he warns that an industry started behind a *substantial* tariff does not experience the competition needed to make it efficient, and if it can only survive by protection it does not add to, but actually decreases, the national income.

JOSSLEYN HENNESSY

Pneumatic Support

Hover Craft. By ANGELA CROOME. *Brockhampton Press.* (15*s*)

This is a good " picture book " and the text is well written, but it is a pity that the aeroplane, the helicopter, the jet VTOL aircraft and the " hovercraft " are treated as successive improvements, with the ornithopter as a sort of ideal. It is true that the aeroplane is the easiest solution to the problem of human flight, but this is so only because it makes the most economical use of the laws of Nature to that end.

The first aeroplanes were to that extent symptoms of increasing scientific knowledge. The essentials of the aeroplane idea are large aerofoils, which are aerodynamically desirable, and a relatively small mechanism (engine and propeller) which allows rapid movements of light parts. Birds and insects are small enough to have the advantages of small mechanisms, but have to do without the aerodynamic advantages of large aerofoils. In any case, neither large fixed members nor continuously rotating parts are suitable to the physiology of animals.

The helicopter may be preferable to the aeroplane for many specialized uses where hovering is important, but it cannot compete for speed or range. It is doubtful if a successful helicopter could ever have been built, were it not for Cierva's idea of flapping freedom for the big, relatively slowly rotating aerofoils. This means that their lifting forces can be transmitted largely by centrifugal forces to the hub, thus allowing the blades to be far lighter than otherwise. Flapping freedom also allows the " disc " of rotation to be tilted about by aerodynamic forces acting on the whole of each blade. Thus ingenuity was able to eliminate a large part of the disadvantage of having a slow and heavy mechanism to rotate the blades. Nevertheless, the helicopter is best as a relatively small aircraft: since the blade-tip speed is practically limited by the speed of sound, the longer the blades the slower must be the rate of rotation.

Now the jet-supported hovering aircraft returns to the small mechanism, but at the expense of lavish power. This is because lift is the reaction from a downward movement of air, and while the lift force depends on mass-flow and flow-velocity, the energy expended depends essentially on the mass-flow and flow-velocity squared. Thus a small fast jet which produces the same lift as a large slow " downwash " must have a higher rate of energy expenditure. Although a jet-supported hovering aircraft is more compact than a helicopter and can fly faster, yet the heat, noise and blast of its jets near the ground, as well as its prodigious fuel consumption, make it necessary to blow much more air through the jet system than is suitable for ordinary jet propulsion at high speed.

Since these jet-lift arrangements are for take-off and landing only, aeroplane-type wings being provided for ordinary flight from one place to another, a high-speed design tends to compromise towards STOL (short take-off and landing). In this way the wings allow a smaller lift from the jets to be acceptable, while the forward movement of the aircraft allows hotter jets to be acceptable.

But even an essentially VTOL design like the " coleopter " uses a fixed wing, though of unusual form, and not a rotating wing as stated in the book. In spite of a clear photograph alongside the text, this aircraft is also wrongly credited with a delta shape. The coleopter stands up on its tail for VTOL, using its normal propulsive jet, and although the annular wing ingeniously serves also as a thrust augmenter in this condition, it is not very efficient either for this purpose or for ordinary horizontal flight.

Finally the book comes to the " hovercraft " or GEM (ground effect machine), which is the only vehicle which really rides on a " cushion of air " and nothing else. This is trapped underneath, either by a low bottom edge round the vehicle or by an annular jet of air blowing inwards, but in both cases the air is in fact escaping all the time along the surface of the ground, and must be replenished fast enough to maintain a pressure under the vehicle higher than atmospheric. Since the escape " slot " for the supporting air is the perimeter of the vehicle, while the supporting pressure acts on the whole bottom area, the larger the GEM the easier it is to do the trick. Since the lift is not essentially dependent on mass-flow and flow-velocity, good design can reduce the energy expenditure to a very low value compared with any kind of true aircraft.

About one third of the book deals with these GEM's and this is obviously the author's main interest so far as the book is concerned. It might have been better to have this as part of another kind of book presenting the three great inventions of history which have no couterpart in Nature, and which seem to have appeared independently in many different parts of the world. The other two are the wheel and the sailing ship. This book is a first edition and has neither index nor bibliography. An index is scarcely necessary, particularly as there is a long list of illustrations, but a list of " further reading " would be useful.

R. C. ABEL

Trade Publications

Copies of any of the following trade publications are obtainable from the addresses given, though distribution is sometimes restricted.

Company Activities

Wedge Belt Drives. J. H. FENNER AND CO. LTD., Hull. " SpacesaVer " wedge belt drives for all purposes, and Taperlock fittings. Range described with power rating tables and installation notes in catalogue. 80 pp. ill.

Dust Collection. VISCO ENGINEERING CO. LTD., Stafford Road, Croydon, Surrey. Dust collectors, cyclones, sleeves, and bag filter types and the Visco-Beth system described with actual examples in brochure. 44 pp. ill.

Oil Gasification. THE SHELL PETROLEUM CO. LTD., 1 Kingsway, London, WC2. The Shell gasification process described in detail with flow diagrams and tables of yields and analyses. 20 pp. ill in colour.

Ethylene Production. KELLOG INTERNATIONAL CORPORATION, 7-10 Chandos Street, Cavendish Square, London, W1. The production of ethylene from light naphtha is described with chemical and financial details in brochure. 16 pp. ill.

" Built by Davy-United." DAVY AND UNITED ENGINEERING CO. LTD., Darnall Works, Sheffield 9. Some of the many items built by the company are illustrated and described with many colour illustrations as well as black and white. There are rolling mills, process lines, and railway wheel plant. Bound volume, 92 pp. ill.

Handling. SIMON HANDLING ENGINEERS LTD., Cheadle Heath, Stockport, Cheshire. Examples of materials handling plant throughout the world; including docks and factories, grain, polymers and iron ore. 16 pp. ill.

Valves. TRENT VALVE CO. LTD., 47 Great Eastern Street, London, EC2. Pipeline valves, cocks, relief, gate, plug and diaphragm types; also gauges and fittings. Catalogue, 130 pp. ill.

New Books

Special Ceramics: Proceedings of a Symposium held at the British Ceramic Research Association. Edited by P. POPPER. *Heywood.* (60*s*)

In response to the growing demand for new high temperature materials a small team was formed at the Association a few years ago to study non-oxide ceramics, working in close cooperation with various government departments and industrial concerns. From the desire to exchange information among a wider circle of active workers there grew the present symposium. The four sessions covered: properties, structures and measurements; nitrides; other non-oxides; and furnaces and techniques.

Structural Concrete. By KURT BILLIG. *Macmillan.* (84*s*)

Following upon his earlier works, *Prestressed Concrete* and *Precast Concrete*, Professor Billig has now produced what he intends as a minor encyclopaedia of the whole field. However, it is not intended to supplant the fuller treatment given in his other books.

Design of Steel Structures. By BORIS BRESLER and T. Y. LIN. *Wiley, New York and London.* (78*s*)

Aiming their book at civil engineering courses, the authors have taken into account the very significant changes in structural engineering over the last three decades, occasioned by much new knowledge in plastic and elastic behaviour, by numerous laboratory investigations and field studies, and by improved materials and techniques.

Video Tape Recording. By JULIAN L. EERNSTEIN. *Rider, New York; Chapman and Hall, London.* (72*s*)

The rapid acceptance of this form of recording in the television industry prompted the Radio Corporation of America Institutes to prepare several courses in the subject in late 1958. The author, who was an instructor at the Institutes, has produced the present textbook to fill a gap which was found to exist.

Spaceflight Technology: Proceedings of the First Commonwealth Spaceflight Symposium, organized by the British Interplanetary Society, 1959. Edited by KENNETH W. GATLAND. *Academic Press.* (75*s*)

A total of 18 papers are here reprinted from the symposium, covering economics, launching vehicles, aero/space vehicles, instrumentation, navigation, tracking, and cabin conditioning for manned satellites.

Taschenbuch für Druckluftbetrieb. *Published for F. M. A. Pokorny, of Frankfurt-am-Main by Springer-Verlag, Heidelberger Platz 3, Wilmersdorf-Berlin.* (*DM* 21)

This book, by Choné, Feiginspau and Gloeckner, is published on behalf of one of the biggest German manufacturers of air compressors and compressed-air equipment. Its 300 pages provide, in pocket-book form, much useful information on the principles, design, performance and operation of compressors and equipment. The final pages take the form of a brochure illustrating the products of F. M. A. Pokorny.

The Reviewers

Mr. G. R. J. E. Leguen de Lacroix, B.Sc., is a design draughtsman with Vickers-Armstrongs (Aircraft) Limited, Weybridge.

Mr. V. H. Brix, B.Sc., A.C.G.I., A.M.I.Mech.E., is a principal scientific officer at the Ministry of Aviation. He formerly specialized in lubrication and bearings, successfully developing air-lubricated bearings, and is a translator of Russian texts and books.

Mr. Jossleyn Hennessy, M.A., is an economist, broadcast commentator and London editor of the *Eastern Economist*, New Delhi. He is the author of several books, including *The European Common Market: What Will it Mean to You?*

Mr. R. C. Abel, A.F.R.Ae.S., is project engineer with Hawker Aircraft Limited and worked under Neville Shute Norway at the Admiralty during the Second World War.

Current Research at NPL

Pioneering research on a number of branches of pure and applied physics was demonstrated last week during the open days of the National Physical Laboratory. Some of the more interesting items are described below.

IN ADDITION to the large number of research projects currently being tackled at the NPL, two important new projects have arisen during the past year. One is for a research and development programme on high speed digital computers, to be carried out as a cooperative effort by government laboratories and industry. The NPL, who are already conducting research into computing elements, would take a major part in this exercise.

The second is a proposal which the Executive Committee has put forward for a research reactor, to be sited at Teddington, for standards work and for basic research by both NPL and the National Chemical Laboratory. The Committee wish to build up the general standards work for radiology and consider that a reactor is an important facility for this. However, since this decision was taken, some adjustment has been made to the order of priority in the purchase of machines for this work. Although the research reactor is going to be needed in due course, initial work will be carried out on a Van de Graaff electrostatic generator.

High Polymer Physics

Polymers are widely used as plastics, synthetic rubbers and fibres and it is of great practical importance to discover the relationship between the structure of their long chain molecules and their electrical and mechanical properties. Work has progressed during the past year on measuring the dielectric properties and the low frequency dynamic properties of polymers.

Autonomics

Control of complicated industrial processes, such as the distillation column in an oil refinery, may be optimised by special computers, permantly attached to plants and "learning" as the inputs and demands change. The first steps have been taken, with encouraging results, toward the building of an exceptionally fast analogue computer of such a kind.

The high speed computer group is working on the development of the planar cryotron as a computer component. This gives promise of much higher speeds, greater reliability and smaller size for computers in the future.

Much of this work is dependent upon the development of techniques and apparatus for depositing fine films of metals and insulators on a suitable base. Apparatus has been developed for the vacuum deposition of both metals and insulators (see illustration) which gives a fine control of the two main parameters, i.e., gaseous impurities and the physical dimensions of each deposit. However, although this apparatus is very good for certain fundamental experiments, more sophisticated devices will be required in the future. In particular, a better overall vacuum, of the order of 10^{-8} mm Hg, will be required. It may also be necessary to carry out mass spectrometric analyses during the next stage of research, in order to make quantitative assessments of the various impurities and their effects on the final product.

The Autonomics Division is also working on the translation of scientific Russian into English, and automatic reading of numerals.

Aerodynamics and Ships

Basic research on hovercraft will be started soon in the Ship Division of NPL. No attempt will be made to design an actual craft, but fundamental data on design and performance will be made available to the firms proposing to enter the field.

Requests for help with the problems of industrial aerodynamics have increased markedly during the year. Particularly interesting work has been done on the wind loadings of roofs in connection with the Mauritius disaster and in connection with a proposed bridge over the River Tagus in Portugal. The Aerodynamics Division has also advised on the planning of new towns and the siting of factory chimneys.

Most of the work of this division consists of fundamental work in fluid dynamics for the aircraft industry. Hypersonic flow now forms a large part of this, and research has also continued on sweptback, slender and delta wings.

Noise

Plans to expand considerably on the present research programme, in view of the mounting national concern about noise have been announced by the Exeutive Committee. Meanwhile, subjective tests on motor vehicles are being made in the Applied Physics Division in collaboration with the Ministry of Transport, aimed at designing an instrument which will give a physical measurement of subjectively assessed noise for a wide range of vehicles. Subjective tests on jet and piston-engine aircraft and helicopters have been carried out. Experiments involving 1,300 people have been made in order to find out whether unpleasantness can be used as a criterion of judgment on disagreeable noises.

Absolute Light Standard

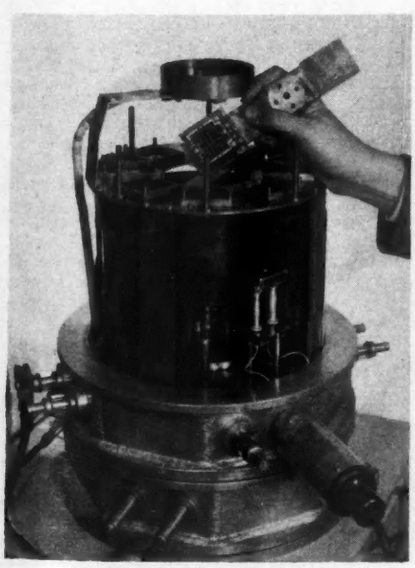
A crucial experiment in the Light Division has been made in an attempt to measure light as a "visually weighted" radiation. This is a radiation which has been passed through a filter transmitting, at every wavelength, a fraction proportional to the sensitivity of the eye at that wavelength. First results were very encouraging and aroused considerable international interest. The Division will now redetermine the NPL radiation scale, after which they may be able to propose the application of an absolute radiometric method to the measurement of light.

A small research group has recently been formed to study optical masers, which are a new and powerful source of coherent and nearly monochromatic light, obtained by stimulated emission in fluorescent crystals. The aim will be to find out what factors control the light output and to build experimental optical masers for pulse and continuous operation, which can be used for research and, possibly, for very fine industrial machining.

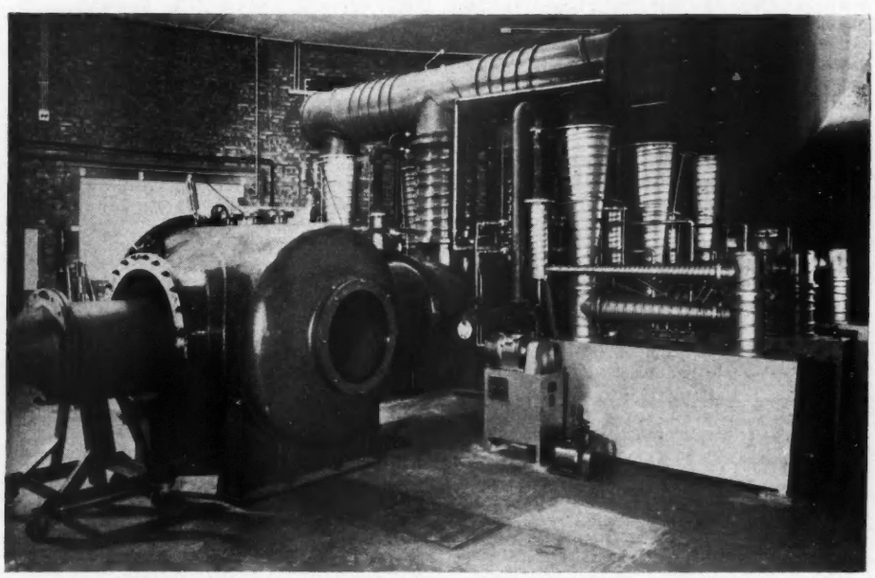
High Temperature Materials

The High Temperature Materials Laboratory has been reorganized and its new programme of research will include a greater concentration on new materials of ultra-high melting point. Initial experiments will be on materials for the first new power stations using supercritical steam and later on more advanced supercritical units.

Progress is continuing in the Basic Physics Division on the effects of materials at ultra-high pressures and temperatures (ENGNG., 28 April '61). Pressures of 100,000 atmospheres, which can cause profound and permanent changes in the properties of certain substances, are now obtainable on the apparatus built at NPL.



Vacuum deposition apparatus has been developed to make cryotron circuits for high-speed computers.



A low-density tunnel is being used for research into problems of flight at high altitudes. Stagnation pressures range from 10^{-4} to 5 atmospheres, and Mach numbers from 0 to 10.

Lift/Thrust Engines for VTOL Aircraft

The Bristol Siddeley BS 53 lift/thrust turbofan engine combines the features of a conventional front-mounted engine with a versatile system of rotatable exhaust nozzles. It may have applications in both military and civil aircraft.

THE original aim behind the development of the turbofan lift-thrust engine was the desire to produce a power plant which would make possible a "flat-rising" single-engined fighting aircraft. Although the Bristol Siddeley BS53 engine (now known as Pegasus) has since found other applications, the original conception was of a low-level subsonic strike aircraft in the 10,000 to 15,000 lb all-up weight class.

One of the first tasks set to the design and development engineers was to devise a single power plant which would be fully effective not only during jet supported take-offs and landings but also during conventional wing-supported take-offs and landings and which would also allow any manoeuvres intermediate between these two extreme cases. The take-off problem itself is summarised in Fig. 1, which displays some of the possible solutions.

The family of curves labelled "A" gives the performance achievable with separate lifting and propulsion engines. It is clear that a large saving in total installed thrust can be achieved, particularly at the V/STO end, by compounding the two thrust components and pointing the resultant in the optimum direction. This rather obvious gain is demonstrated by the curve labelled "B." A further gain is achieved if the thrust vector can be rotated in a continuous manner so as to act in the instantaneous optimum direction throughout a particular take-off manoeuvre. In fact, the curve labelled "C" was calculated on the basis of a simpler assumption, namely, that the thrust vector acts horizontally during ground roll but is rotated at the instant of take-off to point in a direction which then remains fixed until the 50 ft obstacle is cleared.

Curve "C" represents the results of optimising this simple manoeuvre, both with respect to the ground speed at the moment of take-off and to the fixed direction in which the thrust vector is pointed during first segment climb.

Fig. 1 thus indicates the value, not only of being able to rotate the thrust vector, but also of being able to perform this rotation sufficiently rapidly to use different directions for the two phases of the take-off manoeuvre. In fact, on the Bristol Siddeley BS53, the rotation of the thrust vector through 90° is achieved in less than one second.

The considerations of the previous paragraphs could lead to an aircraft of the Bell X14 type, using ordinary pure jet engines with rotatable efflux. However, without underestimating the debt owed to the pioneer work of the X14, it will be clear that this particular solution is very difficult to apply to a practical operational machine.

If VTO is required, and taking into account the total effective installation losses (say, 13 per cent), the required engine(s) will have a total rated thrust of the order of 120 per cent of the aircraft all-up weight. The installed weight of such a power plant could, therefore, hardly be less than 20 per cent of the aircraft all-up weight.

It is difficult to see how a practical aircraft design could be achieved if a weight of this magnitude were allowed to act appreciably forward of the centre of gravity of the rest of the aircraft.

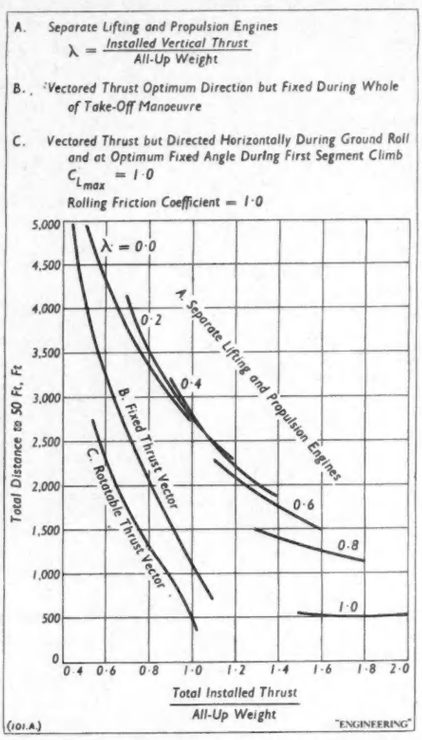


Fig. 1 Possible solutions to the take-off problem.

Further, it is clear that, during VTO the vertically acting thrust line of the engine must go through the CG of the whole aircraft.

Thus an essential requirement of the sort of power plant required is that its thrust line, when vertical, should act, if anything, forward of its own CG.

This could not be achieved with a conventionally mounted pure jet engine except by means of either, (1) ducting a large proportion of the hot exhaust gases forward past the engine, or, (2) using the engine power, not directly as jet lift, but partly to drive one or more independent fans shows efflux could supply lift forward of the engine CG.

The first expedient leads to complicated hot ducting and to certain other undesirable characteristics.

With regard to the second expedient, the choice lies between a single directly-driven fan integral with the engine, i.e., a conventional turbofan engine, and one or more remotely mounted fans which could be driven either mechanically or pneumatically by ducting forward some of the exhaust gases of the main jet engine.

The remote drive solution frees the design of the fans from the contsraint of having to fit in with the main engine geometry and therefore allows an independent optimization of their characteristics. On the other hand this freedom is bought at a great cost in installation complexity. It seemed preferable, therefore, to explore fully the possibilities of the basically more simple turbofan arrangement.

The thermodynamic parameters which fix the engine design are as follows: turbine entry temperature at take-off; high-pressure compressor pressure ratio; by-pass ratio; fan pressure ratio.

The turbine entry temperature at take-off must clearly be as high as possible in order to obtain the maximum ratio of take-off thrust to power plant weight. It is, therefore, determined by the "state of the art" on materials and methods of cooling.

The pressure ratio of the high pressure spool can be determined by balancing the increase in engine weight against the reduction in cruising consumption and this budget will clearly depend on the intended mission of the aircraft. For the applications so far considered a value between 5 and 7 appears to offer the right compromise.

With the selected design of rotating nozzles, the requirement that the vertical thrust line shall not be aft of the engine centre of gravity demands that the thrust obtained from the front nozzles should not be inferior to that obtained from the hot exhaust gases. This imposes a new constraint on the aerodynamic design of the front fan which is not encountered in conventional turbofan engines. A new design parameter, therefore, became of great importance, namely, "thrust split," which is the name given to the ratio of the front nozzle thrust to that from the rear nozzles.

In fact, the by-pass ratio and the fan pressure ratio were selected by balancing the requirements of "thrust split" with the aerodynamic design possibilities of a two-stage fan turbine. This involved complex and difficult decisions, in which thermodynamic, aerodynamic and mechanical considerations were inextricably intermingled.

The upshot is that, for purely subsonic uses, a two-stage fan with a design pressure ratio of the order of 1·9 and a by-pass ratio of 1·4 appears to be suitable, whereas for supersonic applications a three-stage fan with a lower by-pass ratio would be recommended, because of the increased importance of frontal area.

Having outlined above some of the basic ideas behind the lift-thrust turbofan engine, a few of the advantages of the type can now be listed.

Fully Rotatable Nozzles.—These confer on the VTOL/STOL aircraft, all the ground handling characteristics of the conventional jet fighter.

(1) The engine can be run with the nozzles pointing aft, thus avoiding all the bad effects of hot gas recirculation, ground erosion and debris ingestion during engine start-up, ground check and taxi-ing.

(2) During take-off, the nozzles need only be deflected groundwards at the very last second, and in the case of the STO manoeuvre the aircraft will already have acquired some forward speed, so further minimising the effects mentioned above.

The Ducted Fan Cycle. (1) Compared to a pure jet engine, the ducted fan cycle gives large reductions in exhaust velocities and temperatures which are also relevant to the point made in (1) and (2) above.

(2) The good specific fuel consumption of the ducted fan cycle leads to considerable reduction in hover s.f.c. in which condition the fuel consumption of the turbofan engine is half that of the low compression ratio pure lift turbojet engine.

(3) The fact that the required engine is basically of the two-spool configuration can be used to eliminate the gyrocouple of the engine, simply by making the two spools have opposite direc-

Research Report

on the work of

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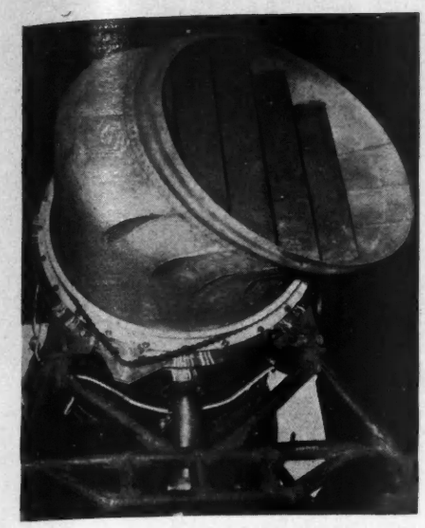


Fig. 2 Early development of bearings was carried out on a single nozzle mounted on the jet pipe of an Orpheus.

tions of rotation.

The Single Engine. The fact that the lift-thrust turbofan type of power plant permits the design of a single-engined VTOL fighting aircraft allows all the advantages in simplicity and low cost of the conventional single-engined machine to be carried over into the VTOL era.

Rotating Nozzle Systems

The four nozzles on a BS 53 are mechanically linked, the drive being provided by duplicated air motors. The pilot selects nozzle angle with a lever in the cockpit whose angle is transmitted to a servo device controlling the air motors.

The torque required to drive the system is determined by a combination of aerodynamic and bearing friction effects. The aerodynamic part of the load is small and results only from assymmetries in the pressure distributions. As the nozzles are disposed symmetrically on both sides of the engine, any residual swirl left in either the fan delivery air or the turbine exhaust gases has no effect on the total torque required to move the four nozzles.

Friction torques depend on the detail of the bearing design. On the present flight engines the total thrust can be deflected through 90° in less than one second with the air motors developing a maximum of about 2 hp.

The early development of the bearings was carried out on a single nozzle mounted on the jet pipe of an Orpheus engine (see Fig. 2). Some early troubles with distortion and difficulties with sealing were rapidly overcome and the latest arrangement has successfully completed 3,000 reversals.

The aerodynamic rig programme has covered thrust coefficient, discharge coefficient and deflection measurement and detailed traverses on seven models (apart from work on varying area contraction ratios and trimming).

The nozzle has two functions—turning and accelerating.

The best performance was a thrust coefficient of 0·98, given by the model in which these two functions were separated by turning in a constant velocity cascade followed by acceleration in a plain conical nozzle. This solution is too bulky and heavy to be of aircraft significance.

Of the other models the next best gave a thrust coefficient of 0·97.

Three models (see Fig. 3) of the hot exhaust "trouser-piece" were tested: (1) an almost plain "T" piece with rounded corners; (2) included an elegant flow splitter; and (3) somewhere between (1) and (2), corresponding to the engine design.

Tested at a representative engine entry Mach number of 0·3 the rather surprising answer was that (1) gave the lowest pressure loss coefficient of 15 per cent. (2) is associated with pronounced loss cores at the bends and had a loss coefficient of 43 per cent. (3) gave 16 per cent. Presumably the bluff back wall on (1) and (3) gives rise to a region of high static pressure tending to maintain flow attachment round the corners. All models gave minimum losses with 3° or 4° entry swirl, which assists turning.

By-Pass Duct

This component turned out to be the cause of the most serious troubles encountered in the early development of the engine. The by-pass duct is the casing which leads the by-pass air from the annular exit of the fan to the circular entries of the two front rotating nozzles.

The original by-pass duct had been developed, purely from the aerodynamic point of view, to give the lowest possible loss of total pressure. In fact, it achieved a loss coefficient of only 15 per cent, which is a surprisingly good result considering the complicated paths through which it takes the by-pass air. Unfortunately, this had been achieved at the cost of distorting the upstream static pressure pattern. The result was to impose a twice engine order forced vibration on the second stage fan rotor blades, which strain gauges immediately revealed to be unacceptably high. The strain gauges showed excessive vibratory stresses at 80 per cent fan r.p.m. which was still far from the critical r.p.m. of 107 per cent at which the blades would be in tune with the excitation, in their fundamental flexual mode.

After trying a large number of palliatives, including some well-founded but ultimately disappointing proposals, the problem has now been settled by means of two modifications.

The careful aerodynamic design of the original by-pass duct has been replaced by a plenum chamber into which two cylinders leading to the rotating nozzles have been inserted, rather like two enormous static tappings. A tremendous improvement to the upstream static pressure distribution was achieved in this way but the cost was an increase in the total pressure loss coefficient from 15 per cent to 58 per cent of the entry dynamic head, resulting in a loss of thrust of 2 per cent.

In addition, the second stage rotor blades have been fitted with "snubbers" at approximately their mean height.

Although these two modifications have led to a mechanically acceptable standard of engine, an active programme is under way to find methods of eliminating the present performance penalties.

Supersonic Applications

The application of the lift-thrust turbofan engine to the single-engined VSTOL subsonic aircraft has been discussed in the previous sections. It is of interest to discuss how this formula can be applied to a supersonic VSTOL aircraft, thus extending to a new generation of F104's and F105's the advantages of vertical take-off and landing.

Mention has already been made of the disadvantage of the large size of the single lift-thrust turbofan in the sea-level subsonic cruise regime: this very feature can now be turned to advantage for high-level supersonic cruising.

In spite of its high thrust to take-off, the unreheated turbofan power falls off too rapidly with forward speed to be useful around Mach 2, but this can be remedied by literally giving the turbofan "a shot in the arm." In this case some fuel is burnt in the by-pass air and raises the front nozzle exit temperature to 1,000° K. It should be noted that this temperature is of the same order as the conventional unreheated turbojet tailpipe temperature and is very much lower than the 2,000° K tailpipe temperature of a modern reheated turbojet suitable for supersonic applications.

The required degree of "by-pass burning" can be achieved within the available volumes and is not incompatible with the rotating nozzle system. By-pass burning can, therefore, be invoked for the VTOL phases as well as for high Mach number propulsion.

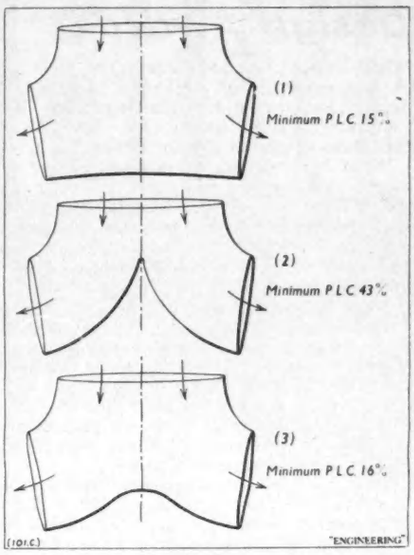


Fig. 3 Three models of the hot exhaust "trouser-piece" were tested.

It is worth noting that even with the modest degree of by-pass burning assumed, the lift-thrust turbofan provides a very powerful means of supersonic propulsion. In particular, the transonic acceleration of an aircraft so powered should be exceptionally good.

In the matter of specific fuel consumption in the supersonic regime the turbofan engine again scores against the pure jet engine. Over the whole useful thrust range, the turbofan has specific fuel consumptions which are better than those of the afterburning turbojet—by 20 per cent in the case most favourable to the turbofan. It is a noteworthy characteristic of the turbofan that its specific fuel consumption is very nearly constant over a 2 to 1 range of thrust.

Having discussed some of the advantages of the lift-thrust turbofan we now come to its major drawback, which is its very large air consumption. If two aircraft of the same all-up weight are compared, one powered by a conventional afterburning pure jet engine with take-off thrust loading of 0·70 and the other using a turbofan with by-pass burning of the type described above, but with a take-off thrust loading of 1·20 (i.e., sufficient for VTOL), it can easily be calculated that the turbofan consumes about three times as much air as the corresponding turbojet engine. The intake capacity, therefore, needs to be three times greater with resultant penalties in drag and intake weight. But it can be shown that, with well-designed intakes, these penalties are more than compensated by the greater efficiency of the turbofan cycle.

Transport Applications

Apart from questions of take-off and landing, it is now recognised that the best engine for high subsonic transport applications is the turbofan, because of its good fuel consumption.

Further, as already explained, the BS53 rotating nozzle system could be fitted to such an engine without noticeably increasing the weight of the power plant. Thus, the ability to rotate the whole propulsive thrust can be provided at the cost only of the slight performance penalties involved in the rotating nozzle system.

It will be uneconomic to increase the size of these propulsive engines beyond a take-off thrust loading of the order of 40 to 50 per cent. Thus, if very short or vertical take-off is required, the lift-thrust engines will need to be supplemented by specialized lifting engines and/or by some method of increasing the lift of the wings. However, even without these aids, the ability to rotate fully the propulsive thrust will by itself lead to a 50 per cent reduction in the take-off and landing run.

Design Awards

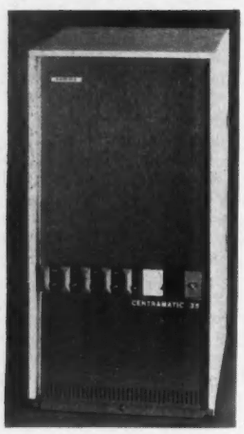
THE DESIGN CENTRE Awards for 1961 are announced this week and among the items chosen are the three illustrated here. The transistor radio set also gained the Duke of Edinburgh's Prize for Elegant Design.

When looking back at products chosen for awards over the past five years, it is clear that the different panels of judges have been attracted by different qualities. This year the judges seem to have been chiefly attracted by line and form and a sound functional engineering approach.

It is an interesting comment that, of the 13 items chosen from among the 3,000 eligible, there are no fabrics, carpets or wallpapers—in fact, hardly anything that relies on decoration except as incidental to the whole design. This choice underlines the trends in product design that take equal note of fitness for purpose and simplicity of manufacture without ignoring the subtler values of good appearance.

Take first the transistor radio. This is made by Ultra Radio and Television Limited and is known as the TR70. It weighs 5 lb including the two 6 volt batteries that have a life of about six months. The carrying handle folds flush with the top when not in use. The award is made to the version with the grey, white and black cabinet and silver grille. High impact polystyrene is used for the cabinet and expanded aluminium for the grille.

The award panel considered that Mr. Eric Marshall, F.S.I.A., had provided a good modern solution to an entirely modern piece of equipment which well illustrated the characteristics of elegance—first, an elegant, precise and economical solution to a problem and, second, a refinement of taste and an awareness of what is appropriate to the times. The panel felt that he had achieved a clean trim and attractive effect in plastics. The contrasting shapes of the two tapers had been carefully proportioned to make them complementary and to produce a slim, elegant composition. The gauge of the metal mesh had been well chosen to be in scale with the other details of the set, and the judges appreciated that the lettering for the trade name "Ultra" had been well chosen and spaced. An adverse criticism was that the function of the tuning control and the volume control could be confused, but as this was a portable radio for personal use, the owner would soon learn to differentiate between them. They also had some doubts about the colours chosen for the controls but they realized that it was necessary to have a contrasting colour here.



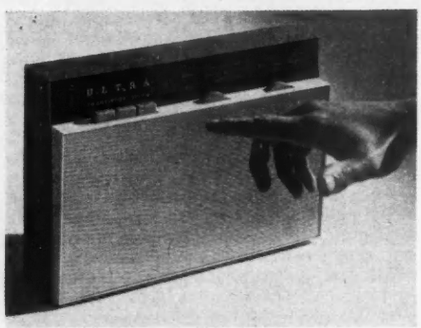
(Upper right) The TR70 radio that was also awarded the Duke of Edinburgh's prize.

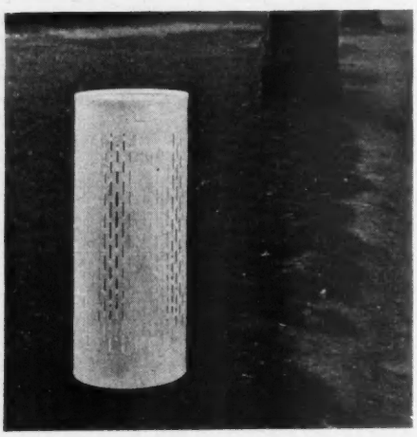
(Left) The Centramatic 35 unit boiler.

(Lower right) A litter bin of perforated metal.

The Redfyre Centramatic 35 (Newton, Chambers and Company Limited) is an oil-fired boiler for the smaller house. It is fully automatic in operation and has an output of 35,000 Btu per hour—enough to supply a 30 gallon indirect domestic hot water cylinder plus some 130 to 200 sq. ft of radiator surface. The burner unit incorporates a fan-assisted vaporizing pot and has electric ignition. Once the required water temperature is set (it is indicated by the lamps on the front panel) no further attention is necessary; the starting, running and shut-down sequence is carried out automatically by a sealed control unit. Pipe connections are from the back or from either side. The height and depth of 36 in by 21 in conform to BS dimensions and the width of 18 in allows it to fit neatly in even a small kitchen.

The judges chose it because they thought it to be a very good example of the type of boiler that is designed as an architectural component that could be related to other kitchen units, as opposed to a free standing object like most boilers. They felt that its simple box-like shape and absence of obvious styling expressed this architectural conception. There is an instrument-like precision in the design of the front panel, brought out most successfully in the anodised aluminium finish which was preferred to the other colour finishes available. They particularly admired the fact that the interior design has been as carefully planned as the exterior. But the judges regretted the tendency in the domestic appliance industry for trade name plates to be so prominently displayed on appliances.





The third item is the "Town Number One" litter bin made by G. A. Harvey and Company (London) Limited. It is described as a cylindrical bin of perforated sheet steel that engages in a fixed heavy gauge steel base incorporating an optional locking device. Various finishes can be supplied. It is 2 ft 6 in high and 10½ in diameter.

It was chosen because the judges thought it was not only attractive to look at and easy to clean but lent itself to use in a wide variety of situations. It is ideal for crowded pedestrian ways where it can also serve as a bollard; it can be sited alongside a lighting column without encroaching too much on usable pavement area; and it is also well suited for large-scale public interiors such as station concourses. The fixing mechanism is neat and simple to operate and the perforations add a feeling of lightness to the design without revealing too much of the litter inside.

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Telegrams: Engineering Lesquare London.

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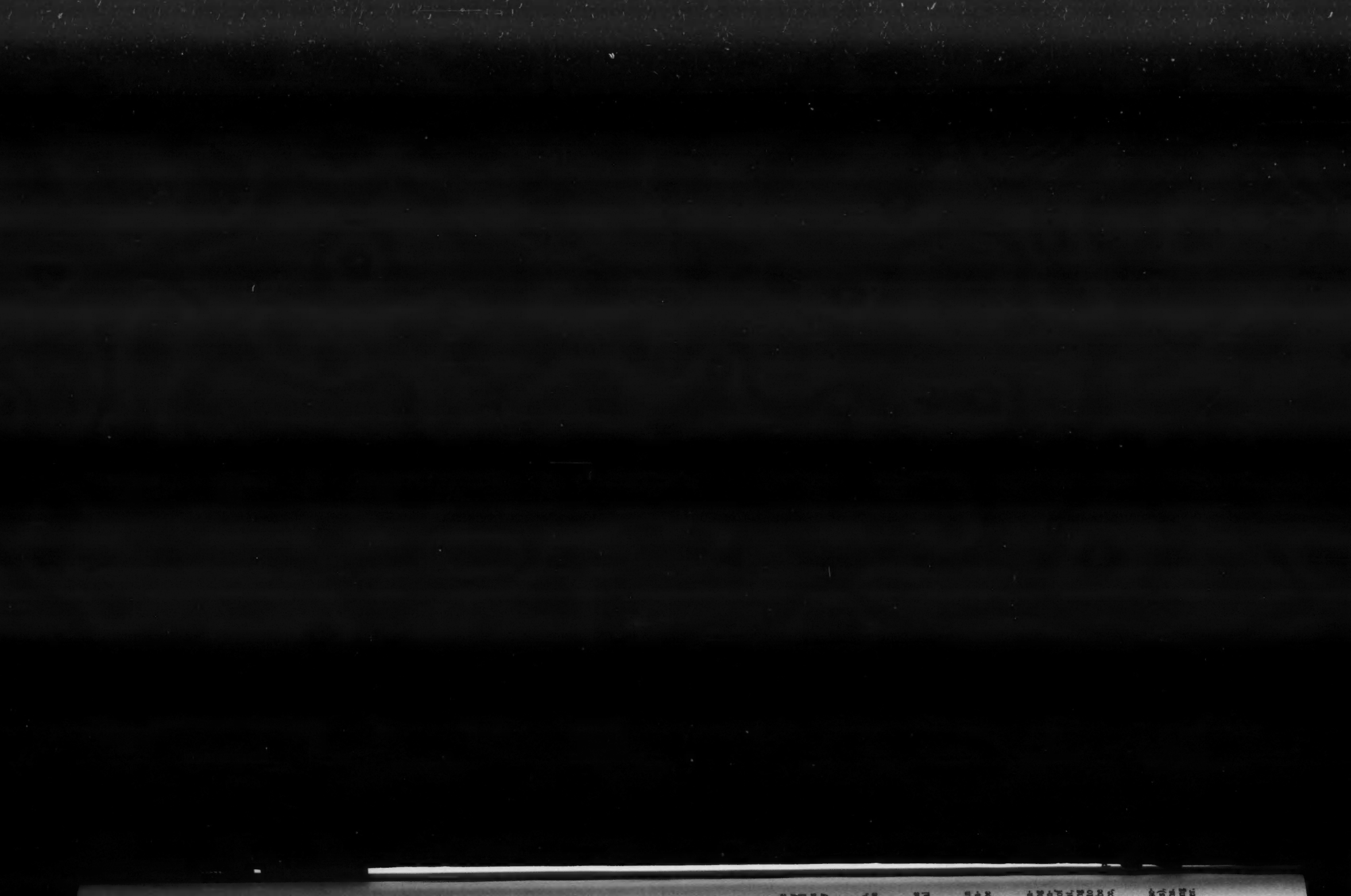
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